THE JUNE SCIENTIFIC MONTHLY

Edited by

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THE SCIENTIFIC MONTHLY

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THE GROWTH OF ASIA

By Dr. BAILEY WILLIS

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TRADITION tells us that Mother Earth is a wrinkled old dame, whose once intense, youthful energies are nearly spent. But tradition is ignorant of those facts which have been discovered through research in physics and geology and which demonstrate beyond question that she is really a vigorous young thing, whose actual activities are quite as intense, or perhaps even more so, than during any past age. We observe, for instance, that there are extensive plateaus, which have but recently, in terms of geologic time, been raised to great elevations. We survey great mountain chains and learn from the forms of the valleys carved in them that they are actually in process of being squeezed up. The Alps, the Himalayas, the Cordilleras of North and South America are young, growing structures, manifestations of tremendous forces, even now at work.

"What is the force that lifts mountains?" I once asked an eminent physicist. He reflected. "Too big," said he. Too big for human imagining, and yet, if I mistake not, it resides in the infinitely small. But of that later.

Youth is, perhaps, not the actual stage of Mother Earth's activities; we might better say adolescence, for she has had her full figure as a planet for two thousand million years that we know of, and the formative stages, whatever they were, presumably occupied a similar lapse of time. We have to thank Madame Curie for that approximately definite knowledge of the age of certain rocks, it being determined from the rate of change of uranium into lead; and now that we have that clue, we learn that the crust of the globe is made up of masses which differ widely in age, some being as much as two thousand million years old, while others date from periods that are not more than twenty millions back of the present. Here, again, our traditional concepts are contradicted. We have long thought of the crust of the globe as having formed by the cooling of a molten sphere, that is at once; any later eruptions were considered minor effects of residual, failing energies of the cooling body. But now we have to recognize that the processes of eruption of the so-called igneous, *i.e.*, melted and crystallized, rocks have been persistently active, not continuously or uniformly, but from time to time, and apparently with but little, if any, diminution of intensity.

This means sustained energy, gradually dissipated by loss of heat, or it means that there is a vast store of energy, from which minor amounts are from time to time released in such a way as to melt bodies of solid rock and to cause them to rise toward the surface,

where they appear as intrusive masses of granite or as extensive lava flows of basalt. Estimates of original heat indicate conclusively that it could not have sufficed to maintain the observed activity during two billion years, and we are led to follow the astronomers, who find the source of the sun's heat and of the internal energy of the stars in atomic changes. The globe contains radioactive minerals, and in them we may reasonably seek the cause of Mother Earth's repeated rejuvenescence.

The old geology, based upon that limited science of physics which led Lord Kelvin to judge that it was more than twenty and less than forty million years ago that the earth solidified, has now to revise many an ancient and once generally accepted theory in order to adjust its hypotheses to the enormous potencies that reside in the atoms. To illustrate the change which is being required in our ideas as geologists, we may review contributions to our knowledge of the geology of Asia, going back a little more than seventy-five years and considering only a few of the eminent scientists who have explored the great continent. As it happens, the writer need name only two among those with whom he has happily been associated.

Raphael Pumpelly in 1863–64 and Ferdinand von Richthofen during the four years 1868–72 opened the records of the geology of China by explorations in that half-a-continent which had been practically closed to Europeans since the expulsion of the Jesuits more than 200 years before. It is interesting to compare and contrast the two. Both were intrepid explorers, equally bold in planning their journeys, equally broad in their interests in the Chinese as a people and in China as a land. But they differed radically in their ultimate purposes. Pumpelly sought knowledge for knowledge's sake. He wished to know the unknown, but he felt no compelling to inform others. Generous of spirit, he gave as freely of his thoughts as of things material and always with the desire that others should derive the greatest possible benefit from the intellectual largesse he scattered liberally. With von Richthofen it was otherwise. He became the guardian of that which he discovered. He felt responsible for it. What he acquired he cultivated. He shared it personally only with those whom he deemed worthy. The difference between the two was temperamental and also racial. Pumpelly, whom the Chinese called the Redbearded Devil, derived from the roving Vikings, happiest when driving carefree down the winds of opportunity, beyond the ken of men. Richthofen was a modern Roman, obedient to the system in which he had been drilled and of which he knew himself to be a leading exponent. They typified the spirits of America and Prussia.

The geologic principles which guided the researches of these two explorers were, however, the same. Their geology was static, in the sense that what was had long been so and had remained unchanged. They recognized the ancient foundations of the continent, the metamorphic and granitic rocks, they identified certain marine limestones and other strata as belonging to one or another geologic age, according to the fossils; they thus began to trace the design of the mosaic of the land, much as an archeologist may study that of a Roman pavement. Many others have followed them, surveying and making maps; British, German, French, Russian, American, Chinese and Japanese have brought their contributions, and the last named have published a complete geologic map of Eastern Asia.

The mosaic of Asia, like that of other continents, has been built up by three

processes; the one, originating within the earth, has contributed the igneous, molten rocks, which have cooled and solidified just below or on the surface; the second is that which by agency of the waters of the seas or atmosphere spreads sediments, forming extensive beds of sandstone, mudrock, or limestone; the third adds nothing to the materials, but it introduces a modified pattern, by compressing the layers so that they become folded, and by shearing through and displacing the more massive bodies of the igneous and metamorphic rocks. The effect of squeezing is generally most apparent in long, narrow belts, each one of which becomes a mountain range or chain, a curving wrinkle on the face of Mother Earth, as if she smiled. In the pattern of Asia the mountain arcs are arranged like garlands, stretched along the southern margin of the Siberian plateau or pendant from one another in ever-widening design toward the south, but diverging east and west. The outermost on the south is the stupendous sweep of the Himalaya chain, skirting the high plateau of Tibet.

The mountain chains of Asia are indeed stupendous. From the days of Marco Polo down to yesterday, when Mallory and Irvine climbed to death on Everest, and long before Marco, back to the time when the first lama aspired to the snows, they have drawn men to the heights, and so also they have dominated the research of scientific explorers. As the slow camel train plodded across the interminable desert flats, the eye sought the distant peaks and the mind dwelt upon the secret of their being. The devout thought of God; the geologist pondered the power and the laws of nature. And so the sands, the rocks beneath the camel's feet were passed over, unnoticed. And yet in them is hidden the record of the growth of the continent. Let us seek to read it.

The rock of the wide spaces is largely granite. Granite, we learn from elastic earthquake vibrations, is the rock that has built up continents. A continent, indeed, may be described as a thin layer of granite floating in solid basalt, the latter being the more common in the earth's outer crust. The layer varies in thickness, from a very few miles to as much as twenty or more in the roots. It is like scum on a melting pot, and the long accepted idea has been that it did originate in and cooled on the surface of the primeval globe. Although we now know that there are relatively very young granites, it is still held by conservative thinkers that they are comparatively very small in volume and perhaps different in origin. That remains to be seen, but it must be admitted that the older masses, now exposed to our view, are much more extensive than the latter ones. It does not necessarily follow, however, that the latter originated differently. The processes in the deep-seated laboratory of the globe appear neither to have changed in method nor intensity and, if molten basalt or other mineral melt can go through a process of gestation, by which its constituents separate to form granite and other kinds of igneous rock, in the earth as in our experiments, the reactions should be the same to-day as always, in kind even though not in volume.

In northern Siberia, in the Gobi Desert, in the plateau of Tibet and in Peninsula India geologists identify very, very ancient granites. Those of India, whose age has been determined by analysis, range from 1,500 million to but 600 million years, and the others are of similarly great antiquity. In eastern China, in the Province of Shantung, and in northern Korea there is also a body of very old, Archean rocks, including granite. The holy mountain, Taishan, is carved from them and the name, Taishan

formation, has been given to all similar masses in Asia.

These granite bodies are the nuclei of the continent. They are of sub-continental dimensions, several hundred miles across, but they are also complex and can best be described as made up of a number of intrusive bodies in a matrix of still older rocks. We find no beginning, only something older than any other record. Large as they are, these nuclei cover only a fraction of the entire land surface of Asia. Between them are wide strips or zones, occupied by younger rocks, which are in lesser part igneous, in larger part sediments. Where the sediments are marine, we know that the waters of the sea flowed between the nucleal lands. As of all ancient history our knowledge of the record is but fragmentary, yet we may say that this was not our Asia, not the continent. It was a group of large, sub-continental islands; and it had that character during many hundred million years.

Without attempting to be exact as to dates, we may say that this Asiatic archipelago, comprising India on the south and Siberia on the north, developed during that most ancient era, the Archean, and during much of the succeeding era, the Proterozoic. Perhaps we should assign to its latest stages the intrusion of a body of granite, known as the Sangkan gneiss, which pushed up in Mongolia, in the region about Kalgan, northwest of Peking, toward the close of the Proterozoic; or we may extend this prolonged series of uptrusions to include one that appeared widely in Mongolia at the very close of the Proterozoic era or in early Paleozoic time, four or five hundred million years ago, when the trilobites reigned in adjacent seas.

Thus, during a thousand million years which we can recognize and during an unknown, preceding era, probably of many hundred millions, northern Asia was being built up on more or less independent granite nuclei and cemented by minor intrusions; while sediments, deposited in the inter-nucleal spaces, covered the basement rocks and became folded into the complex. The area of consolidated, continental land, after the latest Proterozoic intrusion, apparently constituted all Asia as we know it north of the fortieth parallel. But Tibet and Peninsula India remained separate.

During the succeeding two hundred million years of the Paleozoic era the central zone, between Mongolia and Tibet, was for long periods submerged beneath marine waters; it appears at times to have been dry land, as though the bosom of the growing continent rose and fell. But the wide passage between Tibet and India, now occupied by the Himalayas and the Ganges, was traversed by ocean currents, flowing steadily westward, over the present site of the Alps and Pyrenees to the Atlantic. Geologists know that strait, which crossed Eurasia from the Pacific to the Atlantic, as the Tethys. It continued open for another one hundred and fifty million years, down to the beginning of so-called Tertiary time, some fifty or sixty million years ago. It is since that latter date that the great elevations, the mountain chains, such as the Himalayas and Alps, and the high plateaus, such as Tibet, have been thrust up and the continent of Eurasia united from north to south.

But before that uplift of plateaus and upthrust of plateaus occurred, there were manifestations of the internal energy of the earth in the primary form, that of the intrusion of molten granite bodies into the outer crust. As they are now exposed they are relatively small, as compared with the ancient ones, but their wide-spread distribution throughout southeastern Asia suggests an active condition beneath that region in general. These late intrusions first reached sedi-

mentary rocks, whose age is known by fossils, about a hundred million years ago, during the latter part of the Mesozoic era, and they continued to rise during some fifty million years, continuing into the Tertiary. In the island of Hongkong, for instance, there is granite of early Tertiary age.

These young granites have been identified all along the arc of the Himalayas, the Malay Peninsula, Sumatra and Borneo. The young granites are known also, thanks to our able Chinese colleagues, in many localities throughout southeastern China. Unfortunately their surveys have been interrupted and the latest observations remain unpublished. Similar young intrusions, though not always granitic, constitute the foundations of the Dutch East Indies, the Philippines and of the Japanese islands. All the continent lying east, southwest and south of central China, clear out to the marginal island areas, has been filled in by these relatively very recent eruptions to constitute the land of Asia as we know it. Intense activity of the superficial, but deep-rooted, volcanic type is characteristic of the outer edges, toward which the continent has grown. There is every reason to think that it is still growing.

May we not liken the growth of a continent to that of a vast forest? In the earth lie the seeds of granite bodies; being vivified, they become molten, and thrust up, like tree trunks, till their upper branches spread to a wide expanse. Younger growths assemble around the ancient trunk and the crown is widened. There is an analogy, but what is the seed of the molten mass? From what source comes the energy to melt it?

Before this question our older geology stalled. The terrestrial forces, with which to animate old Mother Earth in our speculations, were limited to the attraction of gravity and the residual heat of the hypothetical, incandescent sphere. But gravity is conservative, unless disturbed, and heat is dissipated by conduction, radiation and eruptions. Two billion years! That is a long time to stay hot in cold space, even under the blanket of the atmosphere. Mother Earth should be chilled, stark; like the moon. Why isn't she?

For the past thirty years physics, the science upon which geology depends for its knowledge of energy, has held out the idea that even in the globe, as in the stars, the potential forces of atoms might be released. Radioactive minerals were found and it was discovered that they generate heat. They generate it very slowly, to be sure, but constantly, inexorably, inevitably. Analyses of rocks showed that potent minerals of this kind occur in the crust of the earth in the proportion of about one part in a billion parts. That seems insignificant, but calculation showed that if radioactive minerals were *uniformly* distributed throughout the whole globe in that proportion, it must have melted before the lapse of two thousand million years. The earth is at least that old, but it is not melted. Thus the mathematicians reasoned themselves to a standstill.

But why assume a uniform distribution of any mineral, either for the whole globe or for any particular shell, near the surface or at any chosen depth? The ores of uranium and thorium, the principal radioactive minerals, resemble those of gold, for instance. However convenient it might be according to certain ideals if gold were uniformly distributed, it is not. Let us look at the realities. The earth is an extremely heterogeneous body, especially in detail. The uniform occurrence of any minor constituent is unknown and very improbable. Radioactive minerals occur only as one of the very rare constituents. What if they are and have been quite lacking in some parts, sparsely present

in others, and more concentrated here and there in the huge mass of the globe. The relative richness or poverty in heat generators would determine the rate of production of heat, and rocks which perhaps had cooled, or had never been anything but solid, would melt accordingly, sooner or later.

We may visualize the conditions of melting. In a mass situated at some depth, fifty, a hundred, a thousand miles below the surface, where the temperature of the solid shell is near the melting point, the relatively inert minerals are assumed to be associated with crystals of persistent heat generators. Melting will occur around each active crystal according to its product of heat energy. As the diameter of the effect grows the melt will come into contact with others. The molten mass will enlarge by coalescence. In time, in long time, there will result a body of some size, consisting of the molten rock, of refractory, unmelted crystals, and possibly of unmelted, residual lumps. It will grow *in situ* until it reaches such a size (one to several million cubic miles in volume) that it becomes unstable and must rise because it is squeezed up by the pressure of the walls, which at such depths are overloaded. Its ascent, though aided by the heat of hot gases and currents accumulated toward the top, must be excessively slow, but will continue until the mass reaches a level at which the escape of heat by diffusion, conduction and outflow of lavas exceeds the increment from any contained heat generators. Then the mass will cool and become fixed. But the radioactive heat generators remain and the body will heat up again in the course of a hundred million years or so, unless it is so near the surface that the energy escapes as fast as it is generated. It then becomes a bit of the crust of the earth, which is made up of flattish discs of granitic and basaltic rocks.

Thus I conceive the development of the continent of Asia to have gone on through the ages. I have seen every stage of it, from remotest antiquity to the present; I have seen it as I followed in the footsteps of Pumpelly and von Richthofen, as I motored through India, flew over the Philippines, or journeyed with courteous Japanese colleagues in their volcanic isles; yes, I have seen it —in my mind. But who knows how much is obscured by the mists of time or hidden in the depths of the earth or distorted by my misreading of the record? I can not say, but Mother Earth continues to smile at me with her wrinkled old visage. To explain the wrinkles is another, but intimately related story.

APPLICATIONS OF SCIENCE TO THE METALLURGICAL INDUSTRY

By Dr. JOHN JOHNSTON

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METALLURGY is one of the most ancient arts, and its development has had, and is likely to continue to exert, a decisive influence upon the kind of civilization in which we live. Without metals in considerable quantities we should still be little more than savages in our mode of life; the abundance of their use, which is determined by their real cost, is almost a measure of the standard of living enjoyed by a people. The metallurgical processes in use since time immemorial changed but little, except for a slow increase in the size of units and in the scale of operation, up to about the period in which the steam engine was invented and developed, with the consequent rapid advance in mechanical engineering. In this connection it is interesting to recall that the realization of a practical steam engine was delayed about 20 years because it took Watt that time to make a cylinder in which his piston would move without undue leakage; this is but one of the many examples of the dependence of progress in the industrial arts upon advances in metallurgical knowledge and skill.

The difficulty met by Watt raises a question which I would like to mention, as an illustration of our dependence upon metal tools. How long would it take for a people, reasonably well provided with metallurgical and engineering knowledge but entirely without metal of any kind, set down in an isolated land endowed with all necessary metallurgical raw materials, to develop industry on a scale comparable to that in any of the more highly industrialized countries? My guess is that it would take a far longer time than most people realize, probably half a century or more, even with the intensest application. For the metallurgical art would have to start on the most primitive scale, to produce tools without which the scale of operations could not be enlarged; and this gradual enlargement would proceed very slowly over a period reckoned in years rather than in months. Consider how long it would take them to produce even a crude lathe which would permit of the building of a small steam engine; with a source of power they can proceed on a more rapidly growing scale, and so gradually begin to produce the many shapes and kind of metal articles indispensable to their further progress in the industrial arts. Even at this level of progress they are far below that attained by Russia twenty years ago, and the Russian people have found that, even with a great deal of outside help in the way of completed equipment and tools, a period of twenty years is insufficient to build up to the desired level. Such reflections will be induced in any one who goes through a modern steel mill, and observes the enormous equipment required to produce steel at a cost which permits of its widespread use. The evolution of this equipment has been possible only through developments ranging over the whole field of engineering in the broadest sense of the word. Accordingly, the applications of science to the metallurgical industry cover an extraordinarily wide range, from the principles of physical science on the one hand, to their application to the operation and control of mechanical, electrical, chemical, ceramic and metallurgical processes on the other.

In what follows I shall refer mainly

to steel, and take its development as typical of the metallurgical industry. For this my apology is that steel is the most widely used of all the metals and alloys and that I am somewhat more familiar with it than with the other metals commonly used on a large scale—copper, zinc, aluminum, nickel, lead, tin and their alloys—except perhaps in so far as they are used in conjunction with steel. Moreover, what is said about one metal applies more or less to another, for all are similar in many respects and differ only in detail, these differences being largely what one would expect from the position of each in the periodic classification of the elements, particularly as reflected in melting point and general chemical properties. For instance, lead oxide is easily reduced to metallic lead, iron oxide is considerably harder to reduce, and aluminum oxide is so stable that a somewhat roundabout method is used to make aluminum; yet the principles involved are identical, although the actual methods appear to differ markedly. Further, a given change in the type of crystalline structure of a metal, whether brought about by addition of another element or by mechanical or thermal treatment, will produce the same kind of change in its properties, though with differences in degree depending upon the metal.

Let us return now to the quantitative development of the industry, using iron and steel as typical. A century ago the total yearly production of pig-iron in the United States was only about 25,000 tons, the world production being about two million tons; of this very little was made into, and used as, steel which is an iron-carbon alloy capable of being hardened by heat treatment. Production increased gradually until about 1870, when the utilization of the Bessemer converter and of the open hearth furnace, both newly invented methods of turning iron into steel, brought about a greatly accelerated rate of production of steel. The outcome is that an annual production in the United States of decidedly less than one million tons 60 years ago increased to some 20 million tons 30 years ago and is now potentially nearly 50 million tons. At the same time the price of a ton of steel has dropped from about $160 to $60; that is, in 60 years it has come down to 40 per cent. of what it was, in terms of dollars, and to less than 20 per cent. on the basis of the buying power of the average citizen. The amount of steel now in use in the United States is estimated as being in excess of 1,000 million tons, or on the average, about 18,000 pounds for each person.

I mention these figures to show you that, until recent years, the main effort of the steel industry was centered on satisfying the rapidly increasing demand for mere quantity of more or less standard products. The greatly increased rate of production and the cheapening of the product which enabled consumption of steel to expand so greatly, was made possible by the use of larger and better integrated units, and this in turn by the use of machines to cut down the amount of strenuous labor previously required. These cumulative improvements are due to the efforts of a whole host of men, some of whom made their contribution in totally different fields—as, for instance, in electrical engineering—and with no thought of its application to the production of metals. This labor-sparing machinery has brought about, not a decrease, but an increase in the number of men employed directly in the steel industry; and this has of course been accompanied by a very great increase in employment in those industries using steel in the large quantities made commercially possible by its quality at a low cost. It now looks as if no further *appreciable* lessening of the dollar cost of steel per unit of weight is possible through the use of still larger units or of further labor-sparing machines. On the other hand, the gradual exhaustion of the visible supplies of high-

grade ore will force the use of lower-grade ore, and this will undoubtedly cause some increase in labor cost per unit of weight of metal produced.

It is possible, however, to lower the cost per unit of service by improving the quality of the product, that is, by ascertaining how to make a metal precisely suited to each of the manifold uses to which it is now put. For the city-dweller is literally surrounded by steel in one form or another, yet to him it is just steel. He rarely realizes the fact that the steel in the body of a modern automobile differs in many ways from the steel in railroad rails and in freight cars; in other ways from that in the structural members of great bridges, skyscrapers and ships; and that many special steels are used in machines of all kinds, from agricultural implements through machine tools to high-speed engines. The consequence of this is that steel is made to some thousands of different specifications, each supposed to describe the best steel for the particular purpose. This demand, which in recent years has become much more insistent, for steels of higher quality yet at no higher cost, raises many new problems which have necessitated a fundamental examination to discover what actually happens in each of the long sequence of processes from ore to finished product.

In examining and endeavoring to analyze the processes employed in an ancient art which has already reached a high stage of development, one is likely to meet not only scientific difficulties because the art has far outrun the science basic to it, but also some more or less passive resistance on the part of those who practise the art. The scientific difficulty is to find a sure foundation of fact on which to build; the psychologic difficulty is to get on close enough terms with the practical man to be in position to distinguish between his observations and his inferences. The former are usually right; the latter may or may not be right, largely because there is a nearly universal tendency to simplify unduly by trying to ascribe difficulties in operation to the variation of a single dominant factor, yet with different men upholding different views as to just what that factor is. As a matter of fact, all of them are usually right to the extent that each of these several factors plays some rôle; consequently, in a proper analysis all the factors have to be taken into account and their relative significance to the result assessed with all the means available, whether by statistical analysis or by direct experiment in which one controls as many of the significant factors as possible.

The lag in scientific understanding of metallurgical phenomena was due to the complexity of the phenomena; to the slow development of the requisite experimental technique (a large part of which was initially evolved with quite other ends in view); above all, to the lack of the theoretical principles requisite to a proper interpretation of what is going on, not only in the extraction of a metal from its ore but also in the crystallization of a molten metal or alloy (and metals are used predominantly as alloys) and in the subsequent manufacturing operations. These points we shall now consider more fully.

Half a century ago there had been a great deal of rather scattered investigation of the extraction of metals from their ores, which had led to results in some cases unsurpassed until recently; but there had been little systematic study of the many problems met by any one who tries to correlate and comprehend the behavior of metals and alloys and how this behavior is associated with the previous history of the specimen examined. There had been chemical analysis, often incomplete from the standpoint of present knowledge, which told the relative amounts of the several constituents analyzed for; but these analyses, even though complete, give no information as to how these constituents

are combined with one another, as to what may be termed the molecular architecture of the metal structure. This is, as is now realized, much more significant than the mere gross composition as revealed by analysis; for it fixes the real crystalline structure which in turn determines the useful properties of the metal. This leads me to emphasize that in discussing metal properties, we should aim to relate them primarily to the real structure of the metal and not merely to its chemical composition, this being only one of the factors determining the intimate structure. The consequence is that the validity of many data on metals to be found in engineering and physical tables is open to serious question, not because the measurements as such are unreliable, but because they refer to a particular specimen of a given composition but of unrecorded structure.

Three simple illustrations from other fields will serve to emphasize the point. In the chemistry of compounds of carbon, hundreds of cases are known in which compounds, of identical gross composition, differ widely in properties by reason of differences in the grouping of the atoms, hence in the molecular structure of the compound. Again, diamond and graphite are both composed of carbon atoms, but differently arranged, as has been definitely proved by application of x-ray analysis. The third instance is that a proper mixture of the three oxides, lime, alumina and silica, is of little use as a cement; yet if the mixture is heated to the appropriate high temperature, we get portland cement. The gross composition as determined by analysis has remained unchanged, but at the high temperature, the simple oxides have united to form compounds, dominantly tri-calcic silicate, which is the essential constituent in portland cement. Thus the valuable properties are due to the way in which the several oxides have combined, and this can be told only by the use of methods beyond ordinary chemical analysis.

The key which opened up the whole question of metal structure had been furnished, sixty years ago, by Willard Gibbs, who in 1876 and 1878 presented to the Connecticut Academy the two parts of his memoir entitled "The Equilibrium of Heterogeneous Substances." This great paper is by competent opinion generally considered "among the greatest and most enduring monuments of the wonderful scientific activity of the nineteenth century," and puts its author in the class of the outstanding men, such as Newton or Faraday or Maxwell or Einstein, who have given a new direction to scientific thought. The significance of this paper was immediately noted by Maxwell, who in 1876 wrote that the methods introduced by Gibbs are "likely to become very important in the theory of chemistry" and "more likely than any others to enable us, without any lengthy calculations, to comprehend the relations between the different physical and chemical states of bodies." Apart from this, little attention was paid to this paper until after 1892, in which year a German translation by Ostwald was published. In this way it came to Roozeboom's attention, and thus to general notice, and Gibbs's methods gradually became known to chemists and metallurgists as an indispensable tool in solving the many problems confronting them.

I have recounted this matter, not only to emphasize the great debt which we all owe to Gibbs, but also as a means of bringing out two points. First, that the phase rule—which is the part of Gibbs's work most generally known and most widely applied hitherto—is merely a qualitative statement of the relation between the number of unknowns and the number of quantitative equations which express the conditions of equilibrium; it is properly applied only when we are dealing with equilibrium, and is not needed when all the necessary quantitative data are available. The phase rule is but a part of Gibbs's work, whose quantitative expressions are only now beginning to be ap-

plied to the successful analysis of metallurgical problems. The second point is the long time, fully a quarter of a century, which elapsed between the birth of this idea and its extensive use as a tool in the interpretation and simplification of data which otherwise appeared so complex as to defy a useful or consistent interpretation. Let us therefore see to it that we keep our eyes and minds open for ideas which may assist us in solving our manifold technical problems, even though these ideas may seem to be somewhat highbrow and to have no immediate application to the improvement of our processes and metals. For there can be no doubt that the methods of thought originated by Gibbs have increased enormously our command over processes, enabling us to calculate their efficiency and thereby to get a much better yield of the thing we want; they have entered, directly or indirectly, into almost all lines of manufacture and have thus enriched the world immeasurably.

As these methods became more widely understood, in the early years of the present century, they brought about great activity in the investigation of systems of all kinds, of alloy systems amongst them. The field of investigation was so large and promising, and the number of competent investigators was so small, that most of these studies were, from our present point of view, rather superficial. But for this they are not to be blamed, because their results found immediate practical application and began to clear up many questions which until then had been far from clear. Moreover, they could use only such experimental technique as was then available to them; this, by present standards, was rather crude and was brought up to its present level only by the work of many men working along many different lines, largely without any thought of possible application towards the solution of metallurgical problems.

The development of this technique is worth dwelling on for a moment, as many of you may not realize how recently some of the tools now used every day have been brought to the stage that they are completely reliable if properly used. In the first place, the temperature scale was not definitely established for temperatures above a red heat until about 1910 with the publication of comparisons of gas thermometer readings with the indications of platinum-platinum rhodium thermocouples.[1] At that time it was difficult to get wire for thermocouples which would give reproducible results, and an enormous amount of work went into this general question before it became possible to secure wire for thermocouples of the high quality and uniformity now commercially available; and it was only as this work progressed that men gained confidence in the reliability of the indications of thermocouples properly used. At that time, moreover, it was difficult to obtain satisfactory potentiometers, galvanometers or other accessory measuring instruments; and those which could be bought had to be handled very carefully and were subject to minor troubles of one kind and another to such an extent that it was seldom possible to use them satisfactorily more than two days out of three. Thus it is only within about 30 years that even the best data on high temperatures have been precise enough to have much significance, and still more recently that one could readily obtain instruments which are easy to operate and are reliable day after day.

So much for the measurement of temperature which, as I need hardly remind you, is one of the most significant factors in metallurgical processes, and must therefore be controlled as closely as is feasible. There has also been a great development in apparatus and equipment which enable an object to be heated and maintained at constant temperature for any length of time desired. The point

[1] Indeed the accepted melting temperature of platinum was changed from 1755° to 1773° C. as late as 1931.

is that many operations, involving uniform constant temperature, now readily done have become feasible only recently. To hold a high temperature constant within 1° for any length of time was a feat twenty years ago, but is now commonplace, even if such precision is not always attained when it is supposed to be.

Concurrently there have been improvements in the metallurgical microscope and in the technique of the preparation and microscopic examination of metal specimens, improvements which have enhanced the certainty of interpretation of the observations. This interpretation of structure has been greatly aided by the introduction and development of x-ray analysis which has brought essential certainty in many places where otherwise we would have had to rely on inference. Other refined physical methods which have been applied, or will be made use of, might also be mentioned, but further illustrations are not needed to show how recent is the application of most of the indispensable physical tools in use every day. Moreover, other physical tools are now doubtless in course of being forged, for future use. There has not been a corresponding development of the mechanical methods of test, or in the interpretation of the results of mechanical tests in terms of definite properties of the metal; this seems to be a more difficult matter, but it appears not to have attracted competent fundamental thinking at all comparable to that which has been devoted to physical and physico-chemical methods. There are indications, however, that this situation is becoming more generally recognized, and that these methods of test are going to be scrutinized and studied intensively. At present they can be regarded as little more than conventional tests suitable for ordinary engineering purposes, but measuring an indefinite grouping of properties which can not be definitely resolved into the several components. This was of little consequence when the unit stress in service was low and the factor of safety was high; but it is becoming of significance now when metal is used at high temperatures and pressures, as in high-pressure steam plants or in oil-refining equipment, with a factor of safety coming down towards unity.

Such considerations lead one to the view that many of the experimental data which we are accustomed to regard as reliable may, on critical examination, prove to be less reliable than is supposed; consequently that many of them will have to be redetermined, by modern methods and equipment, with a better real accuracy than has been practicable until recently. To do this involves a great deal of work, attention to many fine points, and in each case the use of all the diverse methods which can be brought to bear upon the problem. A few examples will illustrate the point.

Most metals are used not in the pure state (in which their usefulness would be decidedly limited) but admixed with one or more other elements, which may be metals or non-metals. Since the properties of the resultant alloy depend upon its intimate structure, we must, by appropriate experimental technique, seek information on just what happens when an element is added to a molten metal, which is then allowed to freeze and to continue to cool at an appropriate rate. The results are gathered together in a so-called equilibrium diagram, of the type first proposed by Gibbs. This is in effect a map of the behavior of the system in question throughout the temperature range, on the specific basis that the temperature changes slowly enough to insure that there is always equilibrium between the several phases present; and such a diagram is absolutely fundamental to a proper understanding of how to handle the particular alloy system so as to secure the best results. Now despite all the work which has been put on it, there are still minor uncertainties

in the equilibrium diagram of the iron-carbon system, which is basic for ordinary steels; and there are considerable uncertainties in the diagrams when a third component is present—for instance, manganese or silicon, which are present in all ordinary commercial steels. Indeed, I know of no diagram for a metal system which can be regarded as completely established, and am sure that, when some of the points now in question are fixed, this knowledge will, in some cases at least, prove to be of practical significance.

The defects of the available equilibrium diagrams for metal systems are due largely to the fact that some of the reactions go only slowly, or even very slowly—a fact which has been adequately grasped only within a few years—and consequently, in the experimental work, insufficient time was allowed for the continuous establishment of equilibrium. As an instance, the diagram for the iron-carbon-manganese system was, in part, in error by some hundreds of degrees, because the reaction actually takes weeks to attain equilibrium instead of minutes, as had been presumed. Indeed the significance of time—that is, of the relative slowness of some metallurgical processes and reactions—can hardly be overemphasized; and there is as yet no way of foretelling just how fast any particular reaction will proceed, apart from the general statement that the rate will be greater the higher the temperature, other things remaining equal. The influence of time, or rather of time and temperature jointly, can not safely be neglected in any one of the long sequence of operations between the ore and the finished product; it is particularly marked in the process of heat treatment, the purpose of which is to develop the structure best for the particular use. The rate of response of the metal to certain heat treatments is associated somehow with the size of the crystal grains of which it is made up, or with the temperature range within which the grains begin rapidly to coarsen. In the case of steel the transformation of the structure appears to start at the grain boundaries, hence to go faster to completion when the grains are smaller; whether this is due to material which was thrown out of solution as the grains crystallized from the molten metal and was thus segregated at the boundaries, or to what may be called unorganized atoms at the boundary which belong to neither adjacent crystal array, or to something else, is a question awaiting further investigation which, to be successful, may require more powerful tools than are now available. Whatever be the mechanism in this particular case, one factor in it in the case of steels seems to be a very small proportion (0.02 per cent. or less by weight) of oxygen dissolved in the metal matrix; this may serve to illustrate the precision with which steel must now be made when it has to meet the rigid requirements now more and more often imposed upon it.

A very important phenomenon in which time and temperature enter is that known as aging, which refers to a change in the metal in some cases desirable, in others, undesirable and to be avoided, if possible. This change, in a typical instance, is a strengthening and stiffening of the metal which may proceed over a period of weeks at ordinary temperature, over a period of hours at the temperature of boiling water, and of seconds at some higher temperature beyond which the metal begins to soften. The phenomenon is associated with a precipitation throughout the metal of a very small proportion by weight of finely dispersed, initially invisible, particles of some compound which was soluble in the metal at high temperature but whose true solubility limit has been exceeded at the low temperature. The major part of the effect occurs before the particles are visible under the highest power now available of the microscope; and the effect disappears and reverses

as the tiny particles coagulate to larger particles or are redissolved. The compound precipitated may be an intermetallic compound, as in the case of the high strength aluminum alloys in which the strength is developed by regulating this precipitation hardening; or it may be an oxide or nitride or carbide, as in the case of steel, where the phenomenon is avoided in so far as possible, as it is not unlikely to cause trouble. There is no doubt of the fact that incipient precipitation of a disperse phase in a metal stiffens it; there is no very satisfactory explanation of how this is—but neither is there of any of the mechanical properties of a metal.

As an instance of this, many steels rapidly lose ductility as measured by an impact test—that is, become rather brittle—as the temperature of the steel is lowered towards 0° F. This is of considerable practical importance wherever steels are exposed to impact at low temperature, as in railroad rails in the Northwest in winter and in equipment for the production of low temperature; and care must be exercised in the choice and treatment of steels which will be exposed to such conditions. The temperature range within which this rapid loss of impact-ductility occurs depends markedly upon how well the steel was deoxidized, and to a lesser extent upon the prior heat treatment of the piece. As the temperature is again raised, the steel immediately regains its ductility; this is fairly positive evidence that this brittleness is not associated with a precipitation, but is to be ascribed to the different influence of temperature upon the several properties—cohesive strength, shear strength or whatever they may be—which in combination determine brittleness or ductility. Moreover, whereas the ductility of a certain grade of steel, as measured by impact strength, may be quite low at about 0° F., the ductility of the same piece as measured by elongation under tensile stress diminishes to the same relative extent only at a far lower temperature, and the ductility in torsion remains unchanged even at the temperature of liquid air. Thus there are at least three types of ductility, according as one judges from impact, stretching or twisting, which implies that these correspond to different combinations of the fundamental properties of the crystal aggregate.

What I have said will, I hope, convey to you the idea that some of the useful properties of a metal are influenced by factors which are very elusive and hard to disentangle, even though other useful properties are largely or wholly unaffected. Present research is largely directed towards a better understanding of just what these apparently tiny factors are, and how to control them to the end that the metal will satisfy the multifarious demands of the user. For instance, some properties appear to be influenced by the presence of as little as 0.001 per cent. by weight of some element; and this raises problems of proper analysis, particularly perhaps when the element is oxygen or nitrogen or hydrogen and may occur in more than one form in the solid metal. Moreover, in some cases these tiny constituents are harmful, in others they are needed in the right proportion for best results. That is, for some purposes we require metal as pure as it can be made; more often we seek to get into it—apart from recognized alloying elements—the right small amount of an "impurity" properly distributed through the metal.

This leads to a few words about alloys, in particular about alloy steels. Steel itself is an alloy of the elements iron and carbon; it usually contains small proportions of manganese and silicon and very small proportions of some of the nonmetallic elements, but none of these need concern us at the moment. When certain elements, such as chromium, nickel, molybdenum or vanadium, are added intentionally, the resultant metal is commonly called an alloy steel; but there is no sharp line of demarcation, and usage

is not always consistent. In any case the significant point is that all steels are primarily alloys of the chemical element iron, of which few contain less than 95 per cent., and most contain 98 per cent. or even more; and they owe their range of properties to the peculiarities of the element iron and of the iron-carbon system, peculiarities which are merely modified by the presence of other alloying elements. To discuss this matter would lead too far; it must suffice to say that we now have a fairly consistent general picture of the family of steels, though much remains to be learned about many features in detail.

The properties of any alloy steel—indeed of any alloy—are not a mere matter of its chemical composition; but one has, in each case, to find out just how to treat it to develop its good properties to the fullest extent. Moreover, the treatment best for one property (for instance, toughness) need not be the best for another (for instance, resistance to wear); so that the best securable combination of desirable properties for any particular purpose is usually a compromise. To find a new alloy of superior properties—or even with a single superior property—is far more of an undertaking than is commonly understood. To prepare alloys of a series of compositions is only a starting point for a wide program of investigation to discover the best conditions under which to carry out every one of the many steps between the molten metal and the finished product. Moreover, a new alloy must in general satisfy a wider range of requirements—for instance, it must be weldable and workable, it should have an enhanced resistance to corrosion, it should have favorable properties at high temperature or at sub-zero temperatures—as it is likely to be tried for a wide variety of uses. This means a long period, usually some years, of intensive investigation before it can safely be put on the market, and a much longer period before all its ills have been diagnosed and corrected. One may almost say that there is better information about a new alloy than about the old metal which it displaces, just as there is more definite detailed information about welded joints than about riveted joints; for we must have measurements, and many of them, on the new thing to offset the general experience with the old.

The difficulty of assessing a new metal seems to be quite inadequately appreciated by the many inventors and promoters with patented or secret methods of improving metals, to judge from the arguments they adduce. Some persons go on the principle that a metal will necessarily be improved by additions of some rare chemical element, and the rarer the element the more wonderful is its effect likely to be; or by the use of some "catalyst" discovered by the promoter or his foreign friend—for distance, which is said to make the heart grow fonder, apparently makes the promoter's heart grow fonder of the merits of the project. Others have an almost fanatical conviction that to do something very difficult and costly—such as holding tons of molten steel in a high vacuum—would yield a truly grand product. Those who make such claims are wont to present them without any qualification whatever, and by so doing are likely to impress the man with little or no scientific or technical background, so that they may be believed by him as against the scientist who is unwilling to make unqualified statements until he is sure of his facts—and this, as I have outlined above, may require a great deal of time and effort.

For many years there has been a continuous trend towards a more extended use of lighter products and a more limited use of the heavier products of the metal industry. This is in part merely what one would expect in the present state of evolution of the country as a whole; but in part it is due to the substitution of thinner for thicker material, a substitution which during the last few

years has been going on at a rapidly accelerating rate. For instance, the steel used for automobile fenders is now only half as thick as it was a decade ago, the thinnest part of the finished fender being little more than 0.02" thick. Substitution of thinner for thicker material means that in service the metal is subject to a higher unit stress; and in general it is not safe unless the metal has an appreciably higher resistance to atmospheric corrosion than was required before, for it is obvious that the thinner the metal the greater is the relative weakening of the structure caused by a given depth of corrosion. It is clear, therefore, that a steel to be substituted in order to save weight must—since there can be no appreciable reduction in the weight per unit volume of the metal itself—be both stronger and more resistant to corrosion. The former requirement is not hard to meet at a reasonable cost, the latter is more difficult; it is now receiving a great deal of intelligent attention, and decided advances are being made in the production and application of metals for lighter moving structures.

The essential difficulty is that all ordinary metals (except the so-called noble metals) are essentially unstable in contact with the atmosphere, and tend to revert spontaneously to oxide. This tendency can be hindered only by interposing some sort of barrier between the metal and its environment. This barrier may be an applied electroplate or a coating of paint or other protective material; but it is preferably an oxide film, developed naturally by the metal, as in the case of aluminum, chromium and the chromium stainless steels, which is adherent and impervious, and so prevents further attack. The best way to lessen corrosion in a given type of environment is thus to discover the metal composition which in that environment will develop a film resistant to the progress of the reaction. In this search there is at the moment little to guide us, and we can proceed only by long-time tests on long series of compositions and treatments, carried out under different types of atmospheric conditions. For corrosion, depending as it does upon the environment as well as the composition and homogeneity of the metal surface, is not one problem but a multitude of problems; and so a test made under one set of conditions, as in an accelerated laboratory test, is not a trustworthy guide in predicting the rate of attack under another set of conditions even when the differences might seem to be slight. There is therefore a large problem, the proper solution of which awaits further knowledge of precisely what happens in the atomic layers at the surface of a metal in contact with any environment. With such knowledge it should be possible to find a means of developing on the metal the right kind of protective film.

Perhaps I should point out that metallurgical advances in the direction of making available stronger metals with better resistance to corrosion are, while a direct benefit to the public, in a sense against the interest of the industry in that ultimately they will lessen the amount of metal needed for replacement. For instance, the useful life of a freight car made of some of the newer steels promises to be about twice what it has been; beyond which these cars, being lighter, carry a heavier pay load and are cheaper to operate. Again recent improvements in railroad rails, together with the fact that the railroads are using heavier rails in their main tracks, have enhanced safety, and at the same time the useful life of an average rail has risen from about 10 to perhaps 15 years, according to recent estimates. If this estimate is correct, it means that the rails needed for replacement will be not more than $1\frac{3}{4}$ million tons annually, whereas the eight rail mills in the United States can produce about 4 million tons.

In many applications of metal there is, of course, severe competition between the

several metals—for instance, between steel and brass or copper pipe, or between aluminum alloys and stainless steel for light-weight moving structures; and in others, there is increasing competition between the metals and non-metallic materials such as artificial plastics and composite sheets and boards. Each industry is trying to enhance the merits, and lessen the defects, of its entry in this competition; and the public is the chief gainer. All this means that the metal industry is in effect forced to improve the serviceability of its product, even though the outcome of this improvement is the obsolescence of its mills and a lessening of the amount which it is called upon to supply, at a profit margin almost certainly smaller than it was before.

In conclusion, the general situation, as I see it, is that applications of scientific method have brought, and are bringing, marked progress in the winning of metals and in the treatment of metals, the latter particularly in the sense of developing the best composition and the best treatment to fit a given type of alloy to a specific set of requirements. In the eyes of the general public the changes may not have been very spectacular; yet many metal products, though still called by the same name, have been so much improved in serviceability that they are in effect new products for which new names would not be out of place. These improvements come before the public not as such, but as largely unrecognized contributions to striking developments in the transportation industry, or the chemical industry, or the oil industry—indeed, in all industries, for there are few, if any, which remain untouched by metallurgical progress. Such improvement will continue, quite possibly at an accelerating rate; for there is an enormous field much of which has been little more than scratched. Present indications are that the next decade or two will see progressive improvement in the smelting and handling of metals, and gradual changes in the alloys used for the severest service; but that no *radical* change in the industry is in sight. A radical change seems unlikely except as a consequence of the development of some new idea in pure science; and the development of a novel idea into commercial practicability and use on a large scale will require at least a couple of decades, to judge from past experience. Where this idea may arise, what it may be and whither it will lead can not be foretold; it may well appear in a field entirely different from any now being studied by men concerned with the progress of metallurgy. A telling illustration of this is that if a commission of the most forward-looking scientists then living had been appointed a century ago to study methods of improving artificial lighting, it is highly unlikely that even the most visionary member of the group would have suggested a study of the electric current. I would hesitate to make any prediction, beyond this, that in the immediate future, progress in metallurgy will continue, probably at an accelerated rate, in the directions which I have endeavored to outline to you. That there will be changes is certain; what any of these changes will be is unknown, even to those most interested in planning for the future, and if we knew, we would be preparing to put those particular new ideas into practice as soon as possible.

UP MOUNT KINABALU

II. Camping and Collecting in Lumu Lumu and Beyond

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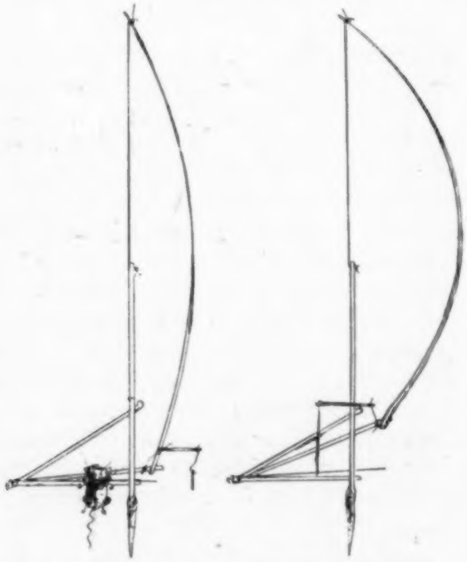
AFTER what seemed like a short climb compared with previous days, I came face to face with my new camp at Lumu Lumu. A small clearing had been made in the thick jungle where a hut stood. It was some thirty feet long by fifteen wide. Its walls were covered with bark and rattan leaves, while the roof was of the Kabu leaves. At one corner and adjoining the hut my little wall tent was pitched on a platform of rough-hewn logs. To the right of the clearing a small icy-cold brook appeared for a few feet and then was swallowed up by the jungle. The whole open area was not more than thirty feet wide and a hundred feet long, with stumps everywhere and felled trees piled on one another. This open space was to afford us a little sunshine on those so few days that we were blessed with it.



DUSUN RAT TRAP, SPRUNG AND SET

Labuan and his fellow villagers had certainly done a grand job. With parangs, a little larger and heavier than butcher's knives, they had felled trees two feet in diameter, made a house, floored it with logs and built a waterproof roof—all in two days.

After a few days I saw why previous scientists had never spent more than ten nights here, because day after day it rained, the mist came down, and it grew bitterly cold. My men were sleeping under six blankets, the fire was kept going continually, and I wore woolen stockings and a thick woolen sweater, while my skinner almost sat on the fire in his efforts to do his work. Undoubtedly the first Dusun word I learned was "Sejouk," which was repeated a hundred times a day and means "darn cold."

At this time I well remembered what Mr. F. M. Chasen, of the Raffles Museum in Singapore, had said about Lumu Lumu. "A colder and damper and a more miserable place I have never been in. I really feel that it was after that trip that I lost my real love for camping." He was there for about ten days. Mr. Evans was of the same opinion, as he said to me when I left Jesselton, "I hope you block up your trail well before you leave as I don't want to see Lumu Lumu ever again." At first I shared their opinion, but I grew to like it as time went on and the weather improved.

Trapping here was very poor, but since I knew that every rat and squirrel that

I caught could be found nowhere else except on this famous mountain, before I left I had over one thousand traps set, stretching in all directions. It took three men a half a day to visit all the traps, for some of them were over two hours away. Since a set of traps was only good for two weeks at the outside, they had to be frequently moved to an untouched district, for on some days all the traps were empty.

Realizing within three days that my factory-made traps were absolutely useless, I went native and used nothing but the Dusun bamboo contraptions that caught anything from a frog to an animal weighing two pounds. It would be a difficult matter to give an intelligible description of how one of these traps works, but they vaguely resemble a guillotine wherein a piece of bamboo, descending from above, pins the rat by the neck to a lower horizontal piece. The motive power is supplied by a bow-shaped piece of bamboo that acts like a spring. These traps are easy to make, light, efficient and easy to set.

The native method of placing these snares is very interesting and can clear out a district in short order of anything that walks or crawls on the ground. They are set in long lines some ten or twenty feet apart. The intervening spaces are blocked up with brush, logs or anything that is handy, to a height of from six to eighteen inches, to form a continuous wall sometimes a mile in length. Thus, any animal wishing to cross over must pass through one of the openings where a trap is ready to catch it. This sounds easy, but it takes a lot of experience to know where to set a trap in order to get the best results and cover the trails of a creature as small as a rat.

The Dusuns being very fond of rat pie and being excellent and persistent trappers, it is of little wonder that certain ground-loving birds, like the red-headed partridge, are almost extinct and are now only to be found in the remotest districts.

PACKING UP TO GO HOME

The excessive dampness of Lumu Lumu was something we had to contend with day in and day out. It was impossible to start a fire without first drying the wood in the sun or on a rack over

DUSUN WOMEN IN GALA REGALIA
AT THE TENOMPOK MARKET. DAUGHTER ON THE LEFT, MOTHER ON THE RIGHT.

the fire and, even so, the fire had to be kept going by constant blowing through bamboo tubes. Likewise all skins had to be kept in a sort of tent cupboard with a fire in it, or a lantern burning to take some of the humidity out of the air. Whenever the sun shone, everything was put outside to dry. Sometimes they were taken back and forth four or five times a day when rain threatened.

Practically every day we had visitors from Bundutuan village. Men and children brought vegetables, snakes, bats, birds, animals, shells and fish for sale, though soon they came less and less frequently, as they told me it was too far to bring a few frogs. I soon solved this new problem by giving them large bamboo containers with the proper solution of formaldehyde which enabled them to collect a large number of specimens before making the three-hour journey to my camp. This idea at once met with their approval and was most profitable to both them and me. Soon fish, shrimp and shells came in by the hundreds, and frogs, snakes and lizards by the tens. As I paid a much higher price for mammals, it was to their advantage to come with only one or two. An animal the size of a badger, civet cat or monkey commanded the highest price.

At least one or two men of a group of visitors would have their blowpipes with which they would "pepper" any little bird they saw. Blowpipes are made from some very hard wood and were formerly drilled out by water power from a large log and then whittled down to the right dimensions. The art of making blowpipes is very specialized, so that only a man having two is willing to sell one. Either darts or clay pellets are used, and in the hands of a good hunter their accuracy is astounding. A match box stuck on a stick at fifteen paces was hit once in every three tries and a chicken at seventy feet was a "walkover."

Monkeys at Lumu Lumu and lower down were scarce, the crab-eating monkey (*Macaca irus*) being the most common. The pig-tailed macaque was also to be found. There were three varieties of langurs, of which the red langur was the most spectacular with his beautiful Irish Setter pelage. Gibbons were heard on several occasions, and one was collected. One day, very close to camp, Labuan saw a large orang-utan.

I had several Italian bird-net sets, but they took a great deal of time to keep in running condition. They did, however, catch several bats that I was unable to procure in any other way. On one occasion "Minnie," my pet monkey, got loose and became terribly tangled up in the meshes of one of the nets set near the camp.

"Minnie" was seldom without company, because I bought several pet macaques from the natives. A little four-months old baby named "Pesang," which is the Malay for banana, was most amusing. Never being tied up, he would make sallies on the kitchen to the depletion of our banana supply. Minnie's failing was Lifebuoy soap, when occasion afforded a chance for her to reach my washstand. Minnie and Pesang were inseparable companions, the former taking a motherly care of the latter, carrying little Pesang around and spending hours in vain search for fleas.

Evenings in camp were never monotonous. While I sat and wrote up my catalogues or skinned, one of the natives would play the "Sumpotan," a musical wind instrument made from a gourd with bamboo pipes set into it. The pleasing sound it produced was like a small organ, far preferable to most native contraptions that pass as musical instruments.

On frequent occasions these peaceful hours before retiring were rudely disturbed by a yell from one of the men as he jumped up and scratched himself, and

PAKA CAVE IN THE FOREGROUND
WITH THE AUTHOR'S SHELTER IN THE BACKGROUND, 9,700 FEET.

CLOSE-UP OF PAKA CAVE
GINDA SATU IN DOORWAY.

CAMP AT PAKA CAVE, WITH DUSUN HELPERS
LEFT TO RIGHT: TONGAL, LABUAN (HEAD BOY AND NATIVE GUIDE), GINDA SATU, AND GINDA DUA.

then would ensue a frantic search with a long pair of forceps for the offender, which was usually a centipede of astounding dimensions that had been so bold as to take a nip at somebody's bare leg. Its final destiny was the collecting bottle of alcohol kept handy for just such occasions.

Almost every night a weird cry was heard near camp and, as the days rolled by without being able to discover its identity, many theories were advanced as to its origin. First it was an owl, then a civet cat, and finally a flying squirrel, which it proved to be when I at last shot one.

The next to last night that I spent at Lumu Lumu, while I was working, I heard what sounded like a gentle rain close to camp, but knowing that the sky was clear I arose, picked up my gun and headlight, and crept out into the starlit night. Then I discovered it was a shower of small twigs falling from a nearby tree. I switched on my light but failed to see either bird or animal. I was slowly circling the locality, when I suddenly picked up the eyes of a giant flying squirrel. So close was it that I could clearly see its black back with its white tickings. The squirrel was hugging the trunk of a small tree some twenty feet above the ground. In spite of my close proximity I realized I would have to take the chance of blowing it to pieces or losing it completely, because at any moment it would climb upwards on the opposite side from me and then would be lost from sight by a long silent glide that would easily carry it a hundred yards. I aimed a little to one side and fired. Luck was with me, and I picked up my second specimen of

this interesting species. The first one I had shot from the door of the camp early one morning a week previously. The only other known specimen of this giant flying squirrel was collected five years previously by a botanist passing through Lumu Lumu, who had killed one with a stone.

When trapping and shooting slacked off considerably, I decided to change camps and send my personnel to Kiau while I made a ten-days' trip to Paka Cave, two and one-half hours below the summit, before rejoining my men.

Fifty porters, the high priest's son and the high priest's helper arrived on the third of August. Of these, eleven were to carry my equipment to Paka, leave me there, and return in ten days to take me to Kiau. That night the cabin was jammed with men and women who, in spite of the cold, were very jovial. The

INTERIOR VIEW OF AUTHOR'S CAMP AT PAKA CAVE

NOTICE THE POT BLACKING ON THE FACE OF THE NATIVE WITH THE HAT ON. THE AUTHOR IS IN THE FOREGROUND.

place reeked of tobacco smoke and human bodies, and the fire smoked more than ever. During the lulls in the babble of human voices, we could hear the faint jingle of metal from the belts of Bornean five-cent pieces that encircled the waist of every girl.

The following morning, I proceeded up hill to Kemberanga, a small clearing some two hours above Lumu Lumu. On the way, four men and I gathered up traps that I had previously ordered piled up in preparation for this trip. One is supposed to "lose face" if a Tuan carries anything more than his body, but I carried some traps, for I was very anxious to get as many up to Paka as possible, because nobody had ever done any serious collecting on the higher slopes of the mountain.

Arriving at Kemberanga, I found that the sacrifice was finished. It was here that Whitehead is supposed to have spent six weeks in 1887 making that remarkable collection of birds that established his reputation as an ornithologist.

SAYAT SAYAT, 12,000 FEET

ON THE SOUTHWESTERN SLOPE AT THE TREE LIMIT.

BASE OF LOWE'S PEAK NEAR WHERE THE LAST SACRIFICE TOOK PLACE

THE NATIVE ON THE EXTREME RIGHT IS THE HIGH PRIEST'S SON, AND NEXT TO HIM, LABUAN. THE REST OF THE NATIVES ARE PORTERS, WHO ARE WEARING MY CLOTHES TO KEEP WARM.

The five-hour climb to Paka is the most grueling of all the stages. The ascent is steep, the ground is strewn with rocks, and the rarity of the air makes breathing difficult. The trees become more stunted, and pitcher plants of at least four varieties become abundant. Of these, *Napenthes Raja* is the largest and was named after Raja Brooke of Sarawak. It has an egg-shaped pitcher nineteen inches in circumference.

Everybody was glad when we finally reached Paka Cave at an altitude of 9,790 feet. The so-called cave, which is really nothing but an overhanging rock, is on the edge of a small stream, the source of the Kadamaian River. A shower of rain on the bare mountain top is enough to convert this little stream into a raging torrent which comes down in a roar of ever-increasing intensity, so that you have to shout to be heard. Only a person with the very highest sense of cleanliness would venture to bathe in its icy waters. I had my tent and tent fly rigged up on a small platform we made jutting out from the hillside, well away from the Arctic stream, for the cave was no adequate shelter for a ten-day halt.

To make the camp warmer we covered the whole tent with "Kajangs," or palm leaf thatch, which previous expeditions had brought all the way from the coast. The tent fly we left uncovered except for its sides, which permitted the light to filter through, and was essential. Under the fly we had a fire going continually, which kept us fairly warm and by which we cooked. Labuan and another of my regular men, seeing how much better it was than the cave, slept with me in the tent. A sleeping bag which a friend had given me for Christmas was ideal for the mountain, and particularly appreciated upon it. Only a constant fire and frequent administrations of brandy kept our spirits up for those ten damp, cold, bleak days spent at Paka. It rained every afternoon. To make things worse, on the eighth day my helpers ran out of food

HARVEY'S PEAK, 12,860 FEET, SOUTH OF LOWE'S PEAK

and were for leaving me, but I gave them the rest of my rice and, with the addition of roasted rats, it saw them through until the porters returned from Kiau.

The forest around Paka is very thick, damp and mossy. The trees are low, "Leptospermum," a sort of bushy tree, being the most abundant. When dry it burns well but not without a good deal of smoke. Around the tent we cleared a few trees to permit the early morning sun to strike our camp because by eleven o'clock the sun is obliterated by mist and it starts to rain.

I was up at dawn the following morning to climb to the summit with the high priest, his helper, Labuan, and three other porters who volunteered to go along. I also took along three natives with fifty traps each to set at Sayat Sayat, which is a flat place on the very edge of the tree limit. By doing this I would secure a collection of mammals from the top of the mountain down to Kiau.

Above Paka the thick, damp forest ceases and is replaced by a stunted vegetation area in which the forest is more open, drier and much less mossy. This continues to the tree limit in irregular spurs, one of which is Sayat Sayat, where the trees have really become bushes since they are so stunted, and rhododendrons, sedge and two kinds of conifers are also present. While crossing a small gully, Labuan found the dried bones and some feathers of a very large bird which were undoubtedly those of a fireback pheasant, a lowland bird which occurs ten thousand feet lower down.

When we reached the base of Lowe's Peak, the last sacrifice took place by a

ALEXANDRA PEAK, 13,135 FEET

small pool of water. The ceremony was as follows: First the priest arranged small bundles of flowers he and the men had gathered on the way to form in a small circle. In the middle he put two eggs, some tobacco, a certain amount of rice and betel-nut. He then squatted down in front of this array with an enormous bunch of charms which consisted of pigs' teeth, queer twisted pieces of wood, an iguana skull and many other unidentifiable "dojiggers" strung on a string. Spitting vigorously, he started his chant, calling to the spirits of the mountain. At the crucial moment, when it came time to cut off the heads of the two chickens, the sun went behind a cloud, but he was vain and obliging enough to wait for it to reappear so that I could take a picture of him "doing his stuff," while the other Dusuns paid no attention to him and chattered amongst themselves. I could never make out whether the Dusuns were absolutely sincere in their beliefs or whether they were like the old lady who bowed at the devil's name in church because "It cost nothing to be polite and, besides, you never know."

Since by this time all the men were shivering and rubbing their hands together, I distributed shirts, trousers, towels and even a pair of cotton gloves. Filling the canteen for the last time and leaving the priest and two others at the sacred pool, Labuan and I made the steep ascent to the top of Lowe's Peak and the highest point on the mountain, 13,455 feet above sea level and Jesselton, which we could see in the far distance. Immediately below us Lowe's Abyss dropped off for

hundreds of feet—clouds veiled its true depths and one might have been looking in the crater of a steaming volcano. All around such peaks as Victoria, Alexandra and St. John's rose like so many medieval sentinel towers that had defied all attacks of the elements for hundreds of years.

I followed the usual custom of writing my name and date on a piece of paper which I inserted in one of the bottles left there by previous visitors, and no sooner had I finished taking some photographs than the thick mist came down and it started to rain. We hurried down and took refuge under a rock at the foot of the peak, where thirteen years previously Messrs. R. F. Evans and C. R. Sarel had spent the night. They recorded a temperature of 30° F. at 6 A. M., and the sacred pool was frozen over. Soon the rain ceased and we again started downwards, but now the water was running on the bare slopes and it was very slippery.

The following day collecting started in earnest. The rest of the three hundred traps were set and the rats and birds that were caught in the traps at Sayat Sayat were skinned. With the possible exception of a shrew, the only other mammal that is truly a resident of this high, sheltered forest zone is a medium-sized brown rat (*Rattus baluensis*), which was very common. One or two specimens of the same mammals that we obtained at Lumu Lumu were also collected.

Of the birds collected, only three were real residents. Of these a very tame thrush (*Merula seebohmi*), not unlike our American robin, was the most abundant. This thrush was so tame that one of my men actually killed one with a stone. The other two indigenous birds of this high altitude were a green warbler (*Horornis oreophila*) and a small brown timeliine (*Androphilus accentor*). It is a very interesting fact that certain birds and animals which Mr. Chasen, of Raffles Museum, Singapore, had collected here at Paka and at Lumu Lumu, were either totally absent or very scarce, although I spent more time at these two localities than anybody else. It, therefore, seems impossible to quote definitely an altitudinal range for certain species. Undoubtedly this is affected both by food supply and time of the year.

During the whole trip we were all very lucky in the matter of ill-health. Some of the men had fevers, another a toothache, and still others stiff necks and stomach aches. Careful boiling of water and eating only cooked vegetables minimized the chances of picking up dysentery, which was ravaging the country. In the preceding ten months a fifth of the population of Kiau died from this disease alone. One of my men who broke out with ugly sores insisted on treating them with soot from the bottom of our cooking pots which only made them worse.

My last collecting station was at Kiau. The Kenokok Valley, an hour's walk from camp, was an excellent hunting ground of very high old forest. Over 60 per cent. of the specimens collected here came from this district. Squirrels of many varieties were to be found in the locality, ranging in size from the giant squirrel (*Ratufa ephippium*), which was nearly three feet in length, to Whitehead's pygmy squirrel, which was scarcely six inches long. This peculiar little squirrel is confined to Borneo and presents an extraordinary appearance with its bushy tail and long tufted ears of grayish white hairs over an inch long. Kiau is a peculiar locality because its fauna is in a most interesting transitional stage, lowland forms occurring side by side with submontane animals. Lizards and snakes were also very numerous in this locality, there being some twenty different species of each.

LOWE'S PEAK, THE ACTUAL SUMMIT, 13,455 FEET

THE SMALL GOVERNMENT REST HOUSE AT KIAU, 3,300 FEET
WHERE I SPENT THREE WEEKS COLLECTING.

GATHERING OF THE MISTS

DUSUNS AT KIAU

"A BUFFALO AND NATIVE TODDY WERE BOUGHT AND THE GUESTS ARRIVED 'EN MASSE.'"

The natives dropping in at the Rest House each evening and morning gave one a good chance to observe them. The young women, however, were very shy and if they saw you so much as glance at them they would turn their heads and giggle foolishly or move away. My long matted hair and bushy beard may have accounted for some of their shyness, for undoubtedly the majority had never seen a beard before.

While I was staying in Kiau several people brought me gifts of buffalo meat, chickens, eggs and one native hat. To show my appreciation for their kindnesses and hospitality, I gave a farewell feast to the three hundred residents. I bought a plump water buffalo and gallons of native toddy, which was specially brewed for this happy occasion. At dusk the guests arrived "en masse"—three hundred strong.

I arranged a contest of native dancing with prizes. At first all the girls were shy, but, goaded on by the onlookers and in anticipation of a mirror or a bottle of

MOUNT KINABALU FROM 3,300 FEET

"I WAS GENUINELY SORRY TO LEAVE THE MOUNTAIN AND THESE JOVIAL PEOPLE."

perfume, first one pair of girls and then another started in. The music was supplied by a "Sumpotan" like the one we had so enjoyed at Lumu Lumu. The dancing took place in a small circle, and the performance was judged on the action of the feet, legs, arms and fingers. Men specialized in a different sort of dance, which was very fast and featured gymnastics and balance rather than grace and form. They also danced with women, but modified their antics to conform more with the girls, who were quieter and more dignified.

On the 28th of August, shortly after dawn, my little caravan headed for the coast. Trudging behind my porters, I glanced back over my shoulder and a lump came to my throat as I took a last look at this friendly village whose inhabitants had turned out to bid me farewell. Majestically towering in the background with a halo of clouds about its summit loomed mysterious Kinabalu.

THE ORIGIN OF LIBERTY

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THE one thing which we Americans prize above everything else is our liberty. Whether the theme of the political philosopher or the slogan of the politician, the mere mention of liberty strikes a responsive chord in us all. The slightest anxiety lest its expression be curtailed in speech, press or assembly brings immediate protest. It may be only an idea imperfectly worked out in government and society, but we are not here concerned with its philosophical content further than to recommend the famous "Essays on Liberty" written over three fourths of a century ago by the English philosopher and economist John Stuart Mill, whose analysis of the concept is still authoritative. We feel and know it is more than an idea, a reality which we are ever ready to defend with our lives as we did in '76. The fact that we Americans enjoy liberty while we imagine certain other nations do not, and the ever present fear that we may conceivably lose it ourselves, shows that we regard its acquisition as a human achievement somewhere in the past. Few of us, however, realize when the idea first appeared on earth and imagine that in some form or other it has always been here, at least since mankind began to be civilized. But we shall see that this is a fallacy and that long periods of civilized man passed without it, and that liberty was evolved late in historical times by one and only one great people—the ancient Greeks.

Whatever may be our shortcomings in reference to our knowledge of that wonderful race, we all know that the Greeks were the first people of Europe to emerge from the barbarism which surrounded primitive man. But we should also know that the Greeks were by no means the first in the "Western" stream of culture, which has flowed ceaselessly onward from the dawn of history on the Nile and Tigris-Euphrates. For world culture was already old when the Greeks appeared. From Marathon, the first great date in their story, back to Khufu, the Egyptian pharaoh of the fourth dynasty, who soon after 2900 B.C. erected the Great Pyramid of Gizeh, still with its base covering thirteen acres the largest building extant, just as many centuries have elapsed as from Marathon to our time. And Khufu's reign was centuries down the historical current of Egyptian history.

During that long period before the Greeks overcame the menace of Persia at Marathon and Salamis and became the chief actors on the stage of history, great peoples to the south and east of Greece had arisen, developed their types of culture, waned and disappeared—in Egypt, Crete, Sumeria, Babylonia, Assyria, Lydia, and among Hittites, Aramaeans, Phoenicians, Hebrews, Chaldaeans and Medes—collectively with the later Persians known to us as the Ancient Near East. And most of these were the spiritual ancestors of the Greeks, helping to mould the beginnings of Greek civilization, the best of the ancient world.

Only recently have we become really acquainted with this Oriental background of early European history, beyond the fragmentary references to it by the Greek and Hebrew historians; and learned that the Greeks did not spring all at once into the full possession of their genius, but, like every other people in history, reached the heights of their culture by slow degrees, in their upward march receiving all sorts of influences from the peoples of

the Eastern Mediterranean and beyond. While borrowing much from their neighbors their amazing originality soon assimilated the debt and made it their own. As Professor Brunn, of Munich, the great critic of Greek art, once said, they borrowed their alphabet from the Phoenicians, but with it they wrote Greek and not Phoenician.

The decipherment of the Egyptian hieroglyphics, a little over a century ago from 1822 on, chiefly through the labors of the young Frenchman Jean François Champollion, the founder of Egyptology, first opened to scholars the Egyptian records, while the later decipherment of the Mesopotamian cuneiform script completed by Sir Henry Rawlinson in the years 1833 onwards similarly enriched our knowledge of the various peoples of Hither Asia beginning with the Sumerians in the lower Tigris-Euphrates valley who invented it. They passed it on to their successors here and in adjoining areas where it continued to be used for thousands of years, almost down to the Christian era, when it finally completely surrendered to the Phoenician character which with modification we still use.

Only since the turn of the present century, however, and especially in the last dozen years have we really come to know the Oriental peoples intimately through archeological excavations. In 1900 Sir Arthur Evans, the English archeologist, began one of the most remarkable triumphs of archeology—the discovery of a hitherto unknown Bronze Age culture in the Aegean area. For this discovery, extended by the labors of a group of international scholars, literally added an entirely new chapter to history. While we can not yet decipher the Cretan script found on pottery, sealstones and unbaked clay-tablets—at least beyond a few numerals—we know from visible remains that Cnossus on Crete, the great isle midway between Greece and Egypt, was the center of a far-flung sea-power as early at least as the beginning of the third millennium B.C., which lasted on to around 1400 B.C., and still later on the mainland of Greece, its final complete destruction being the work probably of Hellenic invaders. This thalassocracy controlled not only the commerce and politics, but largely the culture of an immense area, extending northward from Crete to sites on the Greek mainland—Mycenae, Tiryns, Amyclae, Corinth, Athens, Delphi, Thebes, Orchomenos—and to various Aegean isles—Melos, Thera, Delos—and to northwest Asia Minor, where at Troy Schliemann in 1870 began his reconstruction of its latest cultural phase, which we still call the Mycenaean Age. This culture had lain hidden from the time when the Hellenes first occupied the lower end of the Balkan peninsula in the second millennium B.C., to our time, a culture only dimly adumbrated by the Homeric poems and Greek folklore and regarded by historians till two generations ago as legendary. And we are still appraising the Greek debt to this Aegean empire.

Since the world war more significant advances have been made in our knowledge of Egypt, Syria, Palestine, Iraq and Persia, which allow us better to understand the immense antiquity of Oriental civilization and the debt of the Greeks and us to it. For excavations have made it increasingly evident that "Western Civilization" is, as V. Gordon Childe has recently phrased it, "but the culmination of a tradition of inventions and discoveries that is ultimately rooted in the Ancient East," whose culture on Nile and Tigris-Euphrates goes back some sixty centuries, as a brief survey of recent finds especially in Egypt, Mesopotamia and India will make clear.

After Howard Carter's discovery in 1922 of Tutenkhamon's tomb in the Valley of the Kings, in the desert opposite Thebes, which brought to light the most sumptuous funerary furniture ever

found, we expected nothing more spectacular from the Valley of the Nile. Since then, however, the last chapter in the story of Egypt has been written, really the first, for it is concerned with the remains found in graves of the Neolithic era. Now for the first time we have real knowledge of predynastic Egypt, the long prehistoric period before Menes, the first of the pharaohs, in the thirty-fifth century B.C. unified Upper and Lower Egypt under one crown. Previous to 1895 Egyptian records did not antedate the Pyramid Age—the third and succeeding few dynasties extending from the thirtieth to the twenty-fifth century B.C. Later, the French explorers de Morgan and Amélanau discovered tombs of the first dynasty, and still later the English Egyptologist Flinders Petrie laid bare some prehistoric graves. More recently, however, Neolithic remains have been found along the Lower and Middle Nile, whose different cultures are named from the sites there excavated—Merimdian from the western edge of the Delta, a culture which seems to have been akin to the Neolithic of South Crete; Badarian uncovered in 1924, and Tasian, both from the eastern bank of the Nile; and still other remains in the Fayûm. The area east of the Middle Nile was then a marshland with forests rather than a desert as in historical times. Tasian is the oldest culture yet unearthed in Egypt, and all three mentioned are the only Neolithic remains yet found and are certainly older than any already known in Europe.

In Mesopotamia Woolley in 1924 found an inscription of A-anni-padda, the son of Mes-anni-padda, the founder of the first dynasty of Ur, or the third dynasty after the Flood as reckoned by native historians. A little later evidence of the older first dynasty of Kish, the first after the Flood, was found and the weapons and implements of these early times showed that a high level of culture was attained here near the close of the fourth millennium B.C. Woolley's further discovery of the royal tombs of Ur in 1928, and evidence of a still earlier local Sumerian flood, whose echoes were brought back to Palestine by the Jews of the later Babylonian Captivity, who, in their account incorporated into Genesis, regarded it as mundane in scope, were as remarkable as Evans' discovery of the Aegean culture of Crete or Schliemann's unearthing of the later Mycenaean. For all these discoveries made it clear that by the close of the fourth millennium B.C. or earlier, a highly trained people here in Western Asia worked in copper and gold long before the Neolithic lake-dwellers of North Italy and Switzerland were building their wattled huts on piles with the aid only of flint implements. Still older prehistoric finds have been discovered by Woolley at Tell al'Ubaid in 1922, by Langdon at Jemdet Nasr near Kish—and later at Kish itself—in 1926, and by German excavators at Erech (Warka) in 1930. The latter, known as "Uruk culture" is midway in time between the other two. These finds disclosed the use of the potter's wheel, and showed that the lower Tigris-Euphrates valley was one of the oldest centers of civilization. More recently truly astonishing finds have been made by Dr. Speiser and the American School of Oriental Research on the site of Tepe Gawra near the ruins of Dur-Sharrukin (Sargonburg) in Assyria. This site, ever since its discovery ten years ago, with its twenty-three strata reaching back to the Painted Pottery People of an unknown Neolithic antiquity, has been rightly regarded as one of basic importance for the cultural history of the most ancient East. By 1937 two thirds of the area of the mound down to and including part of level XVI with its underground kilns have been excavated. Especially noteworthy is the rich culture of level XIII with its acropolis and buildings of

the Ubaid era of Sumeria, which represents one of the earliest known stages in the civilization of mankind, since it can not be later than the close of the fifth millennium B.C.

Nearly as astonishing were the finds from the ruined cities of Northwest India—Harappa on the Ravi and Mohenjodaro on the Indus, which were first published in 1924 by Sir John Marshall, and more fully in 1932 in the work of the same scholar and his collaborators entitled "Mohenjodaro and the Indus Civilization." These show that this part of India, first known to Western historians through Alexander's raid in the twenties of the fourth century B.C., was the seat of a notable culture at least as early as 2800 B.C., centuries before the advent of the Indo-European Hindus, a culture known to have had vital connections with that of Sumeria.

We are not here concerned, however, with these prehistoric and early historical periods, but rather with the developed cultures of the Near East. Here, in the long range of time from the beginnings of dynastic Egypt and the early city-states of Sumeria and Crete down to the passing of the last Oriental empire, Persia, we find astonishing advances were made in many phases of culture, such as government on a big scale, organized religions, codes of law, and, above all, progress in the mechanic arts especially in Egypt. These nations may be said to have made the beginnings and early stages in many fields, some of which were later perfected by the Greeks. They developed the first industries, such as weaving, metal and glass work, pottery, and paper, and they fashioned tools of bronze and later of iron.

The most astonishing advances in the mechanic arts were made by Egyptian engineers in quarrying, shaping, transporting and erecting huge weights of stone, and carving them with hieroglyphics. We need only mention the columns of the hypostyle hall at Karnak still standing to a height of nearly seventy feet, on whose capitals one hundred men could find standing room; the twin monolithic portrait-colossi of the seated Pharaoh Amenhotep III opposite Thebes in Upper Egypt, which, on a pedestal thirteen feet high, originally reached sixty-nine feet; the four colossi of Rameses the Great sixty-five feet in height hewn out of the native cliff over the Nile at Abou Symbel in Nubia; and the granite obelisk of Queen Hatshepsut, the first great woman of history, still standing amid the ruins of Thebes ninety-seven and one half feet high and weighing three hundred and fifty tons. An inscription on the base of the latter tells us that it was quarried, shaped, transported and placed into position in eight months! What granite works in our time with modern equipment would undertake to duplicate such a feat in twice the time? We may say that the Egyptians began and developed stone architecture, as well as sculpture and wall-painting.

Both Egyptians and Sumerians invented writing before the middle of the fourth millennium B.C., an art which has preserved many types of their literature—epic, dramatic, historical, epistolary, religious and scientific. The Egyptians invented a solar calendar as early, perhaps, as 4236 B.C.—called the first date in history—which with changes made nearly forty-two centuries later by Julius Caesar in 45 B.C. and fifty-seven later by Pope Gregory XIII in 1582 still serves the modern world. But we still get our divisions of time into months, weeks, days, hours and minutes from Babylonia.

Irrigation on the modern scale was practiced both in Egypt and Sumeria in the earliest days. The prehistoric canals built by the Sumerians made of their country a fertile and flourishing land down to the time of Hulagu, the grandson of the Tartar conqueror Jenghiz Khan, who destroyed them on capturing Bagdad in 1258 and left the plain of Shinar a desert to this day. The extent of Oriental navigation is illustrated by one achievement, the circumnavigation

of Africa by Phoenician sailors in the employ of Necho, one of the last of the pharaohs, twenty-one centuries before Vasco da Gama. By 1900 B.C., the Babylonians had developed a law-code which antedated that of Moses by centuries—a boon which we Americans do not yet possess. The Persians built one of the earliest of roads, the "Royal Road" from Susa northwest to Sardes, with ferries, bridges, milestones, and inns, over whose length of some fifteen-hundred miles their couriers with relays of horses carried despatches in six days, while ordinary foot-travelers required nearly three months. This was the quickest time down to the introduction of railways a century ago. To-day there are no railways in Persia yet completed, and only a single line in Iraq. Only since the world war has the 500 mile journey from Damascus to Bagdad across the Syrian Desert been shortened from seventeen days, the time taken by the Turkish camel couriers, to about twenty-five hours by auto-bus!

These are only a few of the important things done in the Orient before the rise of the Greeks. Unfortunately, however, we find side by side with these undoubted achievements just as noticeable defects. All Oriental governments, on however vast a scale administered, were invariably after one autocratic pattern of hereditary despotism. The great nobles who acted as ministers of the Great King merely administered the will of their master. Their monarchs were regarded as gods and the people never evolved any idea of democratic rule, responsibility of citizenship, patriotism or freedom. Their social structures were similarly unchanging, early crystallizing into fixed and immobile forms in which the people displayed no curiosity nor made any scientific progress beyond the beginnings of astronomy (and its handmaiden simple mathematics) and perhaps medicine. Their religions, with the exception of Zoroastrianism and Judaism, however well organized with temples, priestly castes, and sacred writings, demanded unswerving subjection to priest and tradition and some of them fostered cruelty and even lust. Outside a few individuals, such as Ikhnaton in Egypt, the first monotheist, Zoroaster in Persia, the founder of a dualistic faith which influenced Judaism and through it our own religion far more than is generally known, and the Jewish prophets, no one was able to break through the fetters of traditional belief.

Art early became more or less mummified through adherence to fixed patterns. It delighted in the colossal and impressive rather than in the beautiful whether in temples, tombs, palaces, statues or obelisks. All lacked the Greek *sophrosyne* or moderation, which made the Oriental peoples incapable of imagining a Parthenon or a Hermes. Even mythology was on a grand scale, sometimes developing into the grotesque as in the story of the Pharaoh Menkaure, who doubled his allotted time on earth by turning night into day. Only in morality do we find reasonable standards. Thus Maspero said the profession of faith in the Egyptian "Repudiation of Sins" was "among the noblest bequeathed to us by the ancient world." Zoroaster taught men a choice of conduct between good and evil, and among the Jews man was believed to be fashioned in the image of Jahweh.

Even the last and, in many ways, the best of these Oriental states, Persia, whose foundation and prosperity were coëval with the Greeks just before the latter's apex of culture in the fifth century B.C., showed little advance over its predecessors, despite the fact that it enjoyed the fruits of their experience of centuries. Its government was of the usual absolute type, though its twenty or more satrapies extending from the Mediterranean to India and from the Black and Caspian seas to the Second Cataract of the Nile and the Indian Ocean covered an area two thirds that of the United States and supported a population well over half of the latter's. However, Per-

sia was the first splendid attempt to organize many races under a centralized government which was strong and equable. Following the example of Assyria and Chaldaea whose political machinery she inherited, Persia allowed some local autonomy and some equality of rights for certain classes of her teeming millions. This was a difficult problem in so polyglot a realm and with such an imperfect system of intercommunication, and yet she made some advances in its solution. Founded by Cyrus the Great, who as vassal prince overthrew the Median Empire in 553–550 B.C., its administrative system was perfected by its third king, Darius, also rightly called "The Great" (522–485 B.C.), since his is one of the best examples in all history of perfecting imperial administration on a grand scale. His system, despite the weakness of his successors, when expansion, the very life of an Oriental state, was replaced by satiety, endured still for nearly two centuries until it was destroyed by the Greek conqueror Alexander the Great. And much of the Persian system survived later—especially in the orientalized Eastern Roman Empire ruled for centuries from Constantinople, and still later under the Saracens and Turks, for it was the best that Asia had produced.

Despite her advances in government, Persia knew as little of liberty as any of her predecessors. Her government throughout remained an autocracy, the Great King ruling, as we can still read on Darius' inscription in cuneiform on the lofty rock of Behistun, "by the grace of Ahuramazda"—the god of light whose viceregent on earth he was. The monarch was tolerant only so long as the satraps fulfilled their duties by aiding in war and paying tribute to Babylon. In spite of some degree of autonomy the satrapies were merely parts of a vast despotism, the land being divided into great estates between the nobles and the temples. Civil and military power was indeed divided between satrap or governor and army commander, as in the later Roman Empire from the time of Diocletian and Constantine, so that both were responsible directly to the Great King. But the satrap's loyalty was ever under suspicion; he was watched not only by the sectional commander, but by a resident secretary, "the King's Ear," who kept the king informed, and, worst of all, by royal traveling inspectors, "the King's Eyes," who spied on both. In such a state, however smoothly governed, there was no chance to develop anything like liberty, and the Persians seem not to have known the concept. For here as elsewhere in the Near East for centuries the people were slaves who did the master's will without protest.

We have said enough to show that one thing was lacking in every one of these Oriental states,—the idea of liberty, political, social, economic, religious. We can find hardly a hint of any such idea from the Sumerian city-states onward to the colossus of Persia. As Hegel, in his "Philosophy of History," has said: "They [the Orientals] only know that one is free" and "the consciousness of freedom first arose among the Greeks." The idea was even absent from the Jews from whose sacred writings we get the beautiful sentiment which can still be read on our Liberty Bell in Independence Hall: "Proclaim Liberty throughout the land unto all the inhabitants thereof." But in its context in *Leviticus* (25, 10) this refers not to liberty in any general sense, but only to freeing the slaves in the fiftieth year of jubilee. Liberty, therefore, formed no part of the Greek inheritance from the Near East. In fact its absence there made the Greeks ever contemptuous of the Orientals, whom they regarded as servile and unmanly. Liberty, then, grew up not in Asia nor Africa, but in Europe among the Greeks whose whole cultural activity was directly motivated by it. For individuality constituted the very center of the Greek character.

Why the Greeks developed ideas so different from those prevalent in the East—

originality, variety, curiosity, sweet reasonableness, and above all independence and liberty—features also appearing in the late Romans and revered ever since, it is impossible to say. Earlier writers tried to account for it, in part at least, by geographical conditions. Thus they liked to contrast the physical features of the Balkan peninsula, in which Hellenic civilization evolved, with those of Western Asia. They pointed out that, though the cradles of culture were the confined valleys of the Nile and the Tigris-Euphrates, still it was the vast plains of Asia, unbroken by natural boundaries and enjoying similar climate and products, which by their very configuration made the powerful Oriental empires possible with their uniformity of culture almost excluding change; and that Greece, on the other hand, broken into tiny valleys by intersecting ranges of hills and surrounded on three sides by the sea, whose gulfs and bays penetrate far into the land and make natural communications, was predestined to just the opposite—variety in climate, products, occupations, governments, and consequently in all phases of culture. Thus Wordsworth, in his Sonnet on "England and Switzerland," calls the mountains and seas the "Voices of Liberty" in these lines:

"Two voices are here; one is of the sea,
One of the mountains, each a mighty voice.
In both from age to age didst thou rejoice,
They were thy chosen music, liberty."

We need, however, only remember the dictum of Hegel, that geography is a conditioning and not a determining factor in the history of peoples. The Greeks loved their mountains and seas and owed much, but not all, to them. Probably they would have evolved the same genius equally well if situated elsewhere than in the Balkans. The modern Greeks live in the same environment, but after a century of independence have shown little approach toward the Periclean standard. It is as hard to explain genius in peoples as in individuals. We need only accept the fact of the Greek genius and its immense consequences to later Europe. To have "invented" liberty, as I like to term it, is, to my mind, the greatest thing the Greeks did or could have done, beside which all their other achievements in thought, art and literature, however remarkable, were secondary. More truly these things grew directly out of their inborn feeling of freedom. But we must also add that without the sustaining strength and genius for practical politics of the later Romans, the Greek idea of liberty, like many other good things for which we are indebted to the Graeco-Roman world, might have been lost literally, and a "new birth of freedom" might have been necessary in a later age. To this greatest of ideas, then, the Orient with its autocratic governments, submissive populations, slavish superstitions, and intellectual bondage contributed absolutely nothing. This alone, the appearance of liberty among them, should be reason enough, it would seem, why we should still know the Greeks and the golden treasures stored up in their beautiful language. For in order to understand ourselves and our own achievements we must know whence and how the initial impulse to Western progress has come.

Liberty, then, was the supreme gift of the Greeks to European culture. This alone will help us to explain many of the encomia on Greece expressed by philosophers, poets and scholars. It will explain why Hegel a century ago spoke of Greece as "that point of light in history"; why Shelley in his "Preface to Hellas" said, if with some exaggeration, "we are all Greeks. Our laws, our literature, our religion, our art, have their roots in Greece"; and why Sir Henry Maine, in his work on "Ancient Law," said "Except the blind forces of nature, there is nothing that moves in the world to-day that is not Greek in origin." We first see the idea dimly adumbrated in the council of chiefs before Troy as described by Homer, but the germ was

older, doubtless brought into the peninsula of Greece from the grasslands of the Danube by the ancestors of the historical Greeks who perfected it. Our whole idea of democracy has come directly from its completion in the "Demos" of Athens, long heard from the open-air assembly on the Pnyx.

Liberty was the mainspring of every phase of Greek culture. Out of it arose the Greek city-state, the only political unit freely accepted by the race down to the extinction of their independence by Macedonia, a unit which, despite its small size and narrow outlook, met their ideal of a population of independent citizens rather than of subjects. Any attempt on the part of one such unit to coerce the rest, as was made by Athens, Sparta and Thebes in succession, was regarded as an outrage against their innate notion of freedom. Its infractions by Athens caused the most melancholy war of antiquity, the twenty-seven years struggle between her and Sparta. Out of the city-state arose the democratic and self-governing spirit of Greece, an ideal still reverenced in many parts of the world. It was the same spirit of freedom which kept Greek religion from dogmas, traditional creeds, infallible revelations and sacerdotalism. They felt that these things would hamper their curiosity and freedom of thought. While the Oriental religions soon crystalized into institutionalism, that of the Greeks helped to make them free and happy. Its unique characteristic was, as Jane Harrison long ago pointed out, freedom from fear, which is a lever habitually used by all other religions. The Greeks regarded speculation as an attribute of the godhead. The goal of their religion was not the practical one of keeping people submissive, but was purely speculative. Freedom also kept the Greeks from tabus and asceticism, for their religion allowed them a sane use of nature's gifts. Their morality, like other features of their lives, was governed by "moderation." Greek ethics was a social and not a religious phenomenon, and the two, ethics and religion, were kept separate and not joined as in other faiths. There was no divine sanction to their rules of conduct, for such rules were the work of human teachers, such as Socrates. Their simple ethics freed them from any deep sense of sin or fanaticism for unattainable perfection. The Greek accepted life, lived here and now, and was little concerned with doctrines of immortality. He hated death as much as we Christians do—but for a different reason. He hated it, but did not fear it.

In their city-state experience which extended over centuries the Greeks came to know most of the historic types of government. Athens, their greatest city, alone in her long story from the prehistoric blending of Ionians and autochthonous native stock down to the time of Alexander the Great, experienced most of these in succession—monarchy, aristocracy, timocracy, tyranny or dictatorship, democracy, imperialism, oligarchy (the "Thirty Tyrants"), and, finally, she with her sister states formed a fragment of Alexander's world-empire, which was founded on their ruin as well as on that of Persia. About the only types of rule she did not know were absolutism and the modern ideas of sovietism and fascism, though Athens and other Greek states in the fourth century B.C. reverenced the "strong man" in politics, in one of whom, Alexander, the whole race finally found its hero. With his vision of a vast world-state Alexander not only transcended the provincialism of the Greek city-state, but the nationalism of his own Macedonia as well. For, while extending Greek culture as the leaven of his new state he at the same time, seemingly unwittingly, destroyed Greek liberty, which had been, as we have seen, its motive power.

Many of the basic political and social ideas of the modern world are ultimately inherited from Greece. We need only mention democracy, aristocracy, representation, political parties and clubs, annual magistrates, "recall of judges" and

impeachment, senates, assemblies, councils, committees and commissions, legislation, constitutions, premiers, demagogues and politicians, the ballot, lot, popular courts, federation (the "Hellenic Leagues") and imperialism. Ostracism or temporary banishment without specific cause we know only by name, but we might use it to advantage in curtailing the power of unscrupulous demagogues. All these things are Greek. Even the Greek city-state itself survives in a larger framework. Its only solution in antiquity was the Roman Empire, whose municipalities corresponded with the Greek units. And these have survived to our time.

Not only did the Greeks in their political and social life have actual experience of liberty, but they were the first to theorize about it. In the words of a recent historian "they wrote the first chapter in human liberty." When we consider how diminutive and narrow the Greek city-state was, we are amazed at the permanency and modernity of the political thought which grew out of it. With the Greek neglect of certain problems which bulk large in our politics—*e.g.*, foreign relations, and their emphasis on others—*e.g.*, the absolute authority of the state over its citizens, it would seem that the Greeks could have little of importance to tell the modern world with its huge cosmopolitan political units.

And yet Greek political ideas, expressed from the time of the sophists in the late fifth century B.C. onward, influenced first the Romans, then the Middle Ages, and finally early modern thinkers to the close of the eighteenth century, and still interest us in the twentieth. In fact one can hardly understand early modern political ideas without some knowledge of their Greek background—such theories as those of natural law, human equality, the ethics of justice as the basis of states, private property, slavery. All these and many more were Hellenic concepts first discussed by Greek thinkers. The Stoic doctrine of universal brotherhood, of an ideal world without distinctions of class, sex or family ties, have played along with Stoic ethics an immense role in Christianity.

In a word the Greeks created the science and theory of politics. They were the first to reason about law, equality, justice, natural rights, and, above all, liberty and how to attain them. They have given political and social science not only its terminology, but largely its content. They thought about the state—its nature and function, the advantages of this and that type of government, the relationship between the state and its citizens, law, education and religion in the state, the right balance between individual liberty and the authority of the state, the distribution of wealth, slavery, and many other problems.

Curiously, it was chiefly in the fourth century B.C. during the political decay of the city-state that political and social thinking reached its height in the two greatest of Greek thinkers—Plato (427–346 B.C.) and his pupil Aristotle (384–322 B.C.). We shall close this essay, therefore, with a brief survey of their political thought. Plato lived through most of the tragic Peloponnesian War (431–404 B.C.), and at twenty-three witnessed the downfall of his native Athens at the hands of the Spartan victors, and the subsequent tyranny of the Thirty Tyrants. Throughout the first half of the following century he witnessed the strife of the city-states down to the beginning of the menace of Macedonia. Such an experience naturally affected his writings. Born of aristocratic lineage he refrained from participating in his city's politics, alienated by the misdeeds of the Thirty and especially by the martyrdom of his teacher Socrates in 399, when he was only twenty-eight. Suspicious of democracy and amid the disintegration of government and religion he turned to philosophy. In his "Dialogs" he discussed many themes—psychology, metaphysics, ethics, mathematics, justice, religion, grammar, rhetoric, logic, educa-

tion, and, above all, theories of government and society. These latter appear for the most part in his masterpiece, the "Republic," whose central theme, the nature of justice which he regarded as the true goal of society and the state, for it alone could bring happiness to all, led him to conceive an ideal state based on education. In fact, he believed that education, music for the mind and gymnastics for the body, was the true function of the state. It occupies so much space in his ideal state that Rousseau said "the Republic is not a work on politics, but the first treatise on education ever written." In his last work, the "Laws," while keeping his earlier ideas on art, trade and finance, he abandoned most of his more Eutopian ones and conceived a more practical state with ideas better adapted to real men. To his pupil Aristotle he left what did not appeal to his idealistic nature—experimental science.

Aristotle, in the Middle Ages revered by the schoolmen who curiously accepted him as the "master of those who know," was born in Macedonia, but lived most of his life in Athens. For a score of years before Plato's death he was student or assistant at the latter's Academy. Then, after several years in Macedonia as tutor to young Alexander, he returned to his adopted city and there opened his own school, the Lyceum, on the slopes of Lycabettus, which he conducted till his exile and death in Chalcis. During his lifetime the greatness of Athens had vanished, but he seems to have evinced little interest in it. His manhood coincided with the chaotic period extending from the death of Epaminondas in 362 B.C. to the almost complete extinction of the city-state liberties at Chaeronea at the hands of Philip in 338 B.C. He lived on through the period of his pupil's conquests and died a year after the young conqueror. Thus, like Plato, he enjoyed a varied experience in politics, though he curiously seems to have been little disturbed by the momentous changes which he witnessed. With his vast learning he organized most of existing knowledge. In addition to writing on many of the topics treated by his master, he also wrote on physics, anatomy and especially zoology, as well as constitutional history, literary criticism and politics. While keeping his independence his works show the influence of Plato, just as the latter in his "Dialogs" shows that of his master Socrates.

The "Ethics" and its sequel the "Politics" are the most important of his works to us. The latter may be called his masterpiece, comparable with Plato's "Republic," and has long been known to English readers in Jowett's translation. It is based on over one hundred and fifty city-state constitutions—even including one of Carthage—apparently compiled by his pupils, only one of which, the "Constitution of Athens," has survived, found on a palimpsest discovered in 1890, and is in effect a critical summary of the political experience of Hellas. While less universal than his master, he is by far the most modern in spirit of any Greek philosopher.

In many ways these two, as would be expected of master and pupil, share similar views of politics and society, while in other respects their thought was diametrically opposed. Both based their thinking on the *Polis* or city-state, which already had passed its usefulness. Indeed Plato's "Republic" has been called by a recent writer not only the *apotheosis*, but the *reductio ad absurdum* of the *Polis*. If this is difficult to understand in so universal a thinker as Plato, who died before Chaeronea, it seems incredible in Aristotle, who lived through the conquest of Greece by Philip and that of Persia by his son Alexander. Still he seems to show little interest in the political changes wrought by Alexander and certainly none in his world-empire. His ideal was still the old city-state, though it had become an insignificant fragment in the new Macedonian monarchy.

Both thinkers followed the sophists in

assuming a natural origin of society as growing out of the mutual needs of mankind—*le contrat social* of Rousseau and other eighteenth century writers. Out of this need Plato derived his division of labor. Both emphasized the basic need of education, and both believed that the happiness of all was the function of the state—in Aristotle's words "a state exists for the sake of the good life," which he regarded as one not of power and wealth, but of virtue. While Plato regarded democracy as a form of license since it presupposed the rule of the least fitted, Aristotle regarded each of the three main types of Greek government—kingdom, aristocracy, republic—as advantageous under different conditions. While believing that monarchy or aristocracy was the best ideally, he believed that the only good practical government was one in which the middle class was supreme, while admitting that this "middle" form of government had rarely, if ever, existed.

Plato believed in communism for his upper class—the governors or "lovers of wisdom." They should hold no private property, their marriages should be supervised by the state, and their children, as in Sparta, should be brought up by the state. This was to give the governors leisure for affairs of state, and so Plato's communism differed greatly from the brand of our time, which aims to abolish poverty and to equalize wealth and is universal for the whole people. Plato was against all ideas of wealth with its contaminating influences. While sharing with his age and race in the belief in the natural inferiority of women, he nevertheless believed that with the proper qualifications they should have equal opportunities and training with the men and should be relieved of the care of children by the employment of public nurses. He believed that marriage should be based on eugenics, and, since he does not include slaves in his Republic, seems to have been against slavery.

Aristotle, on the other hand, criticizes his master's views on communism, for he believed in the retention of private property and the family and, in order to give the citizens leisure for higher development mentally and morally, that they might better perform their duties, he argued for the curtailment of trade and industry. Further he regarded women as inferior to men and slavery as a natural social need for the best life of the citizens, the slave being only an "animate instrument" predestined to his lot by nature itself. He also expressed the modern idea that the bad regulation of property and distribution of wealth was "the point on which all revolutions turn," and believed that the false notion of equality and the lack of balance in society were due to the decadence of the middle class which should act as a mean between rich and poor.

While Plato was interested in formulating his ideas by imagining an ideal state, the first Utopia or ideal society in the history of political thought, Aristotle was interested rather in the attempt to understand the nature of the state by analyzing its various types and constitutions and finding which was best fitted for each. And while Plato believed that rank and service should come from mental and moral capacity, Aristotle thought that there should be no absolute equality, but one proportioned to the contribution of each citizen to the general welfare. By leaving offices open to all without pay he imagined that only the best citizens would fill them.

Enough has been said in this imperfect review to show the depth and modernity of many of the theories of these two great thinkers, the supreme interpreters of many phases of Hellenic thought, and their influence on political and social thought down to our time. And enough has been said also to show that our ideas of political liberty both in practice and theory go back to the Greeks and to no other people.

EPIC OF LIFE

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It is only recently that the human mind has grasped the bold outlines of its own history and that of life on the earth. This triumph of unceasing inquiry into the nature of man and man's place in nature now lifts human beings a grade higher in the scale of living things. The many fragments of this long story of life rest securely in scores of volumes—the tributes of a dozen sciences. Can the contour and import of these many scattered fragments be fitted into a few pages? An answer is attempted in the following paragraphs.

The whole of the drama of life seems to have been performed in a very restricted zone—quite near to the very surface of our small planet. Even bacteria disappear in the upper reaches of the atmosphere, and other life extends downward only to the limits set by the ocean depths. At no earlier time in the earth's history has this been different. Fossil remains of living things are found in coal and rock strata now a few thousand feet beneath the soil on which we walk, but it is clear that these veins were land surfaces or ocean floors when they trapped the dead bodies of organisms. If we could look at the present living world from afar, say from the 24,000 miles, which is one tenth of the distance to the moon, we could rightly sense the narrow pinions of life. On the great sphere which would nearly fill our view to east or west we should then see all life imprisoned in a thin film—a living skin—tightly fitted to the very surface of the earth. As we now know it the entire story of life sticks to the place where there is liquid water; where gaseous oxygen, carbon dioxide and nitrogen abound; and where surfaces can absorb sunlight for a continuous flow of free energy.

Though the story of life is narrowly limited in locality or space it plainly fills an amazing lapse of time, and the year is an inconveniently small unit for reckoning its more significant chapters. Probably longest of all its long chapters was the period involved in forming those minerals and in attaining those conditions of temperature and moisture on the earth's surface which would lead to the building of the first and simplest living matter. When the huge quantity of earth-building material was first split off from the hot sun its temperature, mass and gaseous state gave assurance that hundreds of millions of years must elapse before conditions favorable to the origin of life could exist upon its surface. After its separation from the sun this gaseous matter cooled much faster than before, and although very few chemical compounds could exist in the superheated gases of either the sun or the new-born earth many such compounds were formed while the isolated earth slowly acquired lower temperatures. The formation of this great variety of new chemical substances was essential to the origin of life and also to its maintenance after it had arisen. Mixtures of extremely hot gases such as exist in the sun can not undergo cooling to earth temperatures without chemical union, and some of these stable and durable combinations of heated gases are still being effected within the hot volcanoes of the earth to-day.

When the earth became cool enough to permit water in the liquid state to remain on its surface, this earth of ours not only surrendered to the agent which would thereafter dominate and repeatedly remould its surface—and eventually destroy its daily rotation by tidal action—but it passively built the cradle for life.

Forever thereafter water would accumulate in smaller and larger amounts in millions of pools; and always thereafter water would leach some chemical compounds from the diversified rocks, thus giving these compounds opportunity for ever new interactions in that unrivalled chemical laboratory—an aqueous solution. The forces that chilled a burning earth and formed its first pool of water also decreed that innumerable new combinations of matter—each combination with new properties—would appear on the surface of this planet.

In an almost equally significant way the gases which remained on this cooled earth, together with the sunlight which now became a sole and intermittent source of light and energy, assured a still greater variety of new chemical transformations—because these gases and light rays actively invade water. Under the superlatively favorable conditions of an aqueous medium, and for the first time in all our planetary history, these active agents of the air began their unending work on the water-held leachings of the rocks. Included in the earth's early atmosphere was a great store of prying active free oxygen; other oxygen which had tied carbon to itself and yet maintained the free and gaseous state as carbon dioxide; some hydrogen and rarer gases; and finally, a vast store of passive nitrogen—the nitrogen which had proved so largely immune to imprisonment in the great rock which is the earth, the nitrogen which still awaited the rendezvous at the pool—the water crucible—for nuptials with subtler compounds whose issue would exhibit the properties of life.

The next step in the long march of life attained the formation of organic matter from the plenitude of inorganic compounds and gases already accumulated. Probably in more generous quantity than now the surface of the youthful earth released a simple but very reactive gas, hydrocyanic acid, or HCN. This gas, then as now, on dissolving in water gave rise to many organic and nitrogen-containing substances—such as urea and the amino acid, alanine. From still other sources various organic substances were produced. The action of sunlight on carbon dioxide dissolved in water almost certainly gave rise to formaldehyde, sugars and other organic substance long before any microscopic particle even partially endowed with life arose in the pools and ooze of a warm young earth. Just as they seem still to do this in our time the colored surfaces of some flinty water-cups of a naked earth increased the rate at which the sun's rays built organic substances from carbon dioxide and water. The formaldehyde formed in this way could unite with the nitrate or nitrite dissolved from certain rocks and thus produce the very reactive nitrogenous substance, formhydroxamic acid; this acid, plus additional active formaldehyde, must then have produced a whole series of substances which are to-day the commonest constituents of plants and animals—purine, pyridine and amino acids.

With the creation of amino acids a further step could be taken toward the formation of fragments of brevetted matter—matter alive or partly alive. These amino acids are the blocks from which protein is built, and to this day all living matter is built chiefly of protein. Each molecule or building-block of amino acid has behavior and endowments—chemical and physical properties—which differ from those of any other kind of molecule. Such building-blocks can be put together in an almost endless variety of ways, with each new way yielding a new and different protein—and each new protein having one or more properties possessed by no other grouping of matter. Though nearly or quite two million living species now exist, each with one or more proteins peculiar to itself, probably no more than twenty-five different building-blocks are used in the construction of these millions of different proteins.

With the formation of protein molecules our earth was at the threshold of life. The viruses which cause such things

as colds in humans and mosaic disease in tobacco and asters, are particles of matter too small to be seen with any existing microscope. They are, however, probably pure proteins—and they possess one and only one of the properties of living matter. Under certain conditions they can divide and very exactly reproduce themselves. Though the virus may be said to be only "half-alive," it can be killed; but man, willow, worm and bacteria are killed far more easily. Again, those similarly minute and unseeable particles which in all living things bear the hereditary qualities—the genes—are in several respects similar to virus molecules. Probably both kinds of molecules are proteins; they are of about the same size; they both show a rare and peculiar form of instability or tendency to mutate; and both are able to reproduce themselves only when in contact with larger and more complex molecular aggregates which show all the properties of life. Probably no single gene standing alone is fully alive; but many genes are packed closely together in all living cells, and since the various genes of a cell differ somewhat from each other their very juxtaposition or aggregation may add other elements of "liveness" to the aggregate. All really intimate unions of molecules are known to create properties not present in the uniting components; and gradations in "liveness" do exist. With these developments centering about endless labile compounds of carbon and nitrogen the phase of living substance may be said to begin, and the inconceivably long era that began with a few hot and mutually repellent gases in a burning fragment of the sun was ended.

It was also a very long way from the simplest living cell to the man of a million years ago. But this long way was all the trail and unbroken chain of life, and since man has learned the cogent rule of that extended highway its course can now be roughly charted. In the great lapse of time the many genes within the simple single cells were able now and again to add new genes to the old store. Here each new gene meant a new type of cell—eventually a new race or species if the conditions into which it was born permitted it to live and reproduce. In still other cases cells ceased to separate after their division or reproduction, and the resulting aggregates—these groups of cells—gave rise to several sponge-like animals.

No event in the history of life is more notable than the earliest and unwitnessed case of dividing cells remaining attached to each other, getting mutual benefit from it and preserving this state through all later cell generations. Few of the many primitive single-celled species accomplished this; but those that did provided the possibility for flower and fish and man. In these cell-communities, and also in the single cells which preceded them, there was occasional chance for offspring to start their lives with a set of genes which differed slightly from those of their parent or parents. By whatever means the genes were increased or were changed—and, in experiment, even x-rays have shared in causing genes to change—individuals and races of a new type were produced in that fraction of cases in which the changes were helpful; the luckless bearers of the still more numerous disadvantageous changes quickly disappeared without leaving descendants in the stream of life. Hundreds of millions of years provided many hundreds of thousands of advantageous hereditary changes; and many hundreds of thousands of superior species of plants and animals came to crowd and glorify the earth. Now and again during this period splendid species which had persisted for ages disappeared from the living scene, and their fossil remains tell of such things as changing climates and new enemies—things to which these once living forms could not adapt themselves.

One to five million years ago there were several very superior animal tribes with expanding brains, all assuming more or less upright positions and developing

skilful hands. Somewhere within or near this period one of these tribes markedly outstripped the others and its descendants became paleolithic man. The early performance of this man is not flattering to humanity in general, but probably we could not even approach an understanding of ourselves without some familiarity with this distant human ancestor. He and his neolithic successor reveal very much that is truly inborn and nakedly human—characteristics now much obscured in modern man by a capital thing called "social inheritance."

Primitive man required an unknown amount of time for learning to make a most simple tool—a flint for aid in obtaining food and subduing wild animals. But for hundreds of thousands of years thereafter this paleolithic man apparently made little further progress. Once he had made himself a bit safer from dangerous animals, and was assured of a somewhat readier food supply, he seems to have remained for thousands of generations almost as non-progressive as a population of black bears. If paleolithic and modern man could meet they would be quite incomprehensible to each other; but the milestones between the two ages and the two men tell much. Tool-using man has been doing something on some parts of the earth's surface for perhaps five hundred thousand years. Yet it is probably only within the last fifteen or twenty thousand years that he built his first city. Four hundred thousand years —tool-using man—but no city! A drab epoch of human futility; a brutal demonstration of primal limitations of raw untutored man!

Even the limitations of our somewhat more recent ancestors—those neoliths distant by no more than a thousand generations—are so evident as to require the consideration of factors elsewhere immaterial to the story of life. The man of to-day is or seems so different. How can we bridge the gap between him and his progenitors of thirty thousand years ago? That adjacent ancestor was probably equipped with nearly or quite as good heredity as are most men of to-day. Neither structural changes occurring in man nor changes in the genes carried by him, adequately account for the changes that have occurred in man during the last twenty or thirty thousand years. Those changes came largely from social forces born with an alliance with fire, the discovery and extension of agriculture, the invention of alphabets and wheels, the domestication of animals and the use of metals and harnessed energy. These external things—created doubtless by a clever few and shared by all—brought security, plenty and leisure; and they also supplied the foundations for written language, accumulated experience and able leadership. No human being thereafter grew up as his mere primate self, but from infancy onward he was permeated by much that his race had already accomplished—a thing not possible in any other living species and a thing scarcely evident in primitive man during some hundreds of thousands of years.

Thus the long trail of life leads to modern man—the winner of an age-long race between many brothers. Like the sparrows he arrives not as a single breed but as several. Though these races have not been physically blended by the external or social things of their own creation, they already begin to understand each other. In numbers far greater than at any preceding epoch the living bodies of man now caress the hemispheres. His art and labor have laid a friendly, fruitful, chequered sward upon a planet. His growing mind has gripped the sun, moon and a hidden universe of stars—and wrested speech from buried milestones of his own path of many million years. With the mantle of these triumphs about him modern man now exalts both himself and his hardy groping ancestor who painfully shaped a flint.

THE LAND AND THE PEOPLE

By H. H. BENNETT

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During the decade since this country felt the first impact of world depression, public interest in the problem of land use has become more intense and realistic than it has ever been. Among other things, the depression set us to looking for the causes of economic distress in agriculture; and many of them we found to be rooted in a pattern of land use that was basically unsound. The experience of the depression convinced many people that the recovery and sustained welfare of agriculture would require a drastic renovation of our national land-use situation. The recognition of this need, coupled with dust storms, floods and other unmistakable physical signs of land abuse, has created a keen awareness of land problems in the public mind and brought a general public demand for positive steps toward land reform.

Through the normal processes of democratic government this demand has been translated into public programs of a kind that differ sharply from the traditional. In the past, public agencies relied principally upon research and education to solve the ills of agriculture. To-day, they have moved beyond these fields into the field of action, bringing the resources and facilities of the government into play directly on the land. The result has been to create a new situation, full of new opportunities for dealing with the varied and complex phases of the broad land problem.

Equally significant is the rapidly increasing interest of rural people in the matter of land reform. The inertia, or lack of interest, of the individual which for so long impeded agricultural action has disappeared to a large degree. As a result, agencies of the government engaged in land-use programs are now receiving intelligent cooperation from men who use the land day in and day out. There is a close working alliance between farmers and the government which did not exist a decade or so ago. To-day, the actual land users of the country are beginning to build their own programs of land-use readjustment out of their own grass-root experience. Through soil conservation districts, county planning committees, rural zoning groups and other democratic mechanisms of recent origin, our present-day problems of land-use are being studied and analyzed; action programs are being planned and carried out by farmers themselves with the help of public agencies especially equipped and authorized to assist them. In a very accurate sense of the term, this is land-use action from the ground up. One might say, in fact, that public land-use programs nowadays are *grown*, not *made*, since they spring directly from the land; and are carried out, in large part, by people to whom these needs are a matter of everyday concern.

As a result, it is now possible, through the cooperation of these local groups, to bring public action programs effectively onto the smallest unit of land use—the single field. This in itself is a highly significant fact. Public land-use action must, of course, be broken down into spheres—a national sphere, in which the primary concern is with the broadest realignments; a regional sphere in which readjustments must be made to fit the needs of major segments of the country; a problem area sphere, and so on. Ultimately, there is the smallest sphere—the field.

Attempts to plan and carry out rearrangements of national, regional or problem area land-use patterns will come to

naught unless it is possible to rearrange the pattern of land use on the individual acre of the individual farm.

A region may be unsuited to a given type of agriculture, but its agriculture can be changed only field by field. It may be that the size of farms must be readjusted in a given problem area, but still the readjustments can be made only field by field. The formation of local land-use action groups, empowered to cooperate directly with agencies of the government, federal or state, in formulating and executing plans for land-use reform, brings the public program effectively into this important final sphere of action.

Typical of this extremely interesting trend toward the assumption of land-use responsibility by local people is the growth of soil conservation districts during the last two years. In that relatively short time, twenty-six states have enacted legislation authorizing the formation of these local cooperative land-use organizations. As of November 15, 1938, 103 districts had been formed. These cover an aggregate area of some 54 million acres of privately owned farm and grazing land.

Details of the procedure involved in their creation under state laws are not relevant to this discussion. It will suffice to point out that they are formed voluntarily by groups of land operators for the specific purpose of readjusting and regulating land-use practices in the best interests of the community. The entire process of formation and administration is completely democratic, with ample opportunity for the expression of majority will at every important stage.

Stated simply, the function of the district is to develop and help land operators carry out a program of proper use for all the land within its boundaries. The district itself may undertake to carry out the work; or it may request the assistance

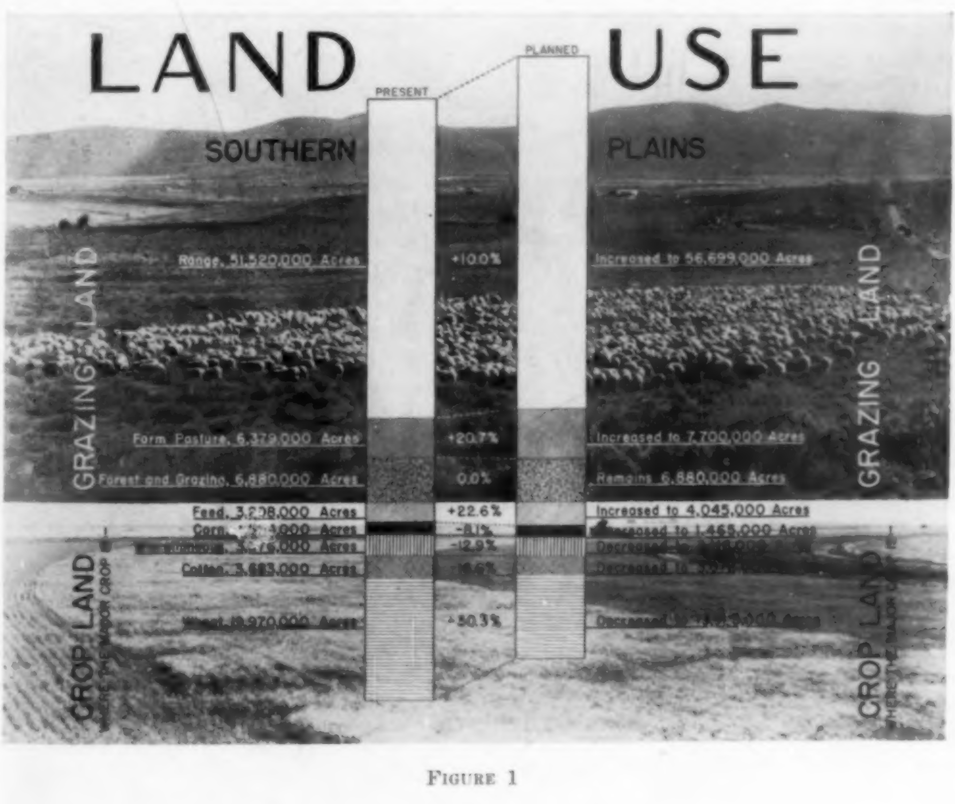

FIGURE 1

of the Soil Conservation Service and other action agencies of the government. Actually, the latter course is usually followed, since districts, in the beginning at least, seldom have the facilities for extensive reorganization of land use.

The program drawn up and proposed by a new district embracing five counties in north-central Georgia will indicate the part these local agencies are now taking in the national land-use picture.

The declared objectives of the program of this district are in general to "enable farmers to raise and maintain a suitable standard of living and to perpetuate agricultural resources within the district." More specifically, the objectives are, first, to bring about the adoption of necessary practices for the conservation of soil resources; second, to make the adjustments necessary to a wise land-use program, such adjustments being directed toward an increased income for individual farmers; and third, to develop necessary land-management practices, such as would provide for the efficient utilization of extra feed and pasture resources resulting from the realignment of farm-cropping systems.

In approaching these objectives, this district proposes a number of land-use readjustments, including an increase in total crop land of approximately 12,500 acres; an increase in pasture land of approximately 7,500 acres; a decrease in woodland pasture of approximately 8,000 acres; a decrease in idle land of about 60,000 acres; the reforestation of some 30,000 acres of eroding land currently in crops; the purchase and development of approximately 200,000 acres of submarginal land; the rehabilitation of some 2,900 farmers through loans by the Farm Security Administration; the protection and improvement of 26,000 acres of farm woodlands; the development of food and cover for wildlife; and the installation of sound conservation practices, such as strip-cropping, terracing, cover cropping and planned rotations on all cultivated land vulnerable to erosion.

Into this district, at the specific request of the district supervisors, the Soil Conservation Service is bringing the facilities of a major public action program. It has the authority to assist in planning and applying soil-conservation measures on individual farms; in establishing good woodland and pasture-management practices; in reforesting or regrassing crop lands retired from cultivation; in purchasing the areas of submarginal land recommended for permanent retirement by the district, and so on. In other words, through alliance between the district, as an agency of the community, and the Service, which administers federal aids to better land use, the people of the five counties are given maximum public assistance in readjusting land use farm-by-farm. Public action is brought effectively into play in making single farm realignments and in fitting them into the larger pattern of desirable land use in the district as a whole.

The Soil Conservation Service is mentioned in this connection simply to illustrate the close and highly effective alliance which is now possible between public agencies and local people. There is no intended implication that the program of public aids administered by the Soil Conservation Service represents more than a partial answer to all problems of land use. Indeed, it seems apparent that no single type of public assistance is adequate to cope with those problems in all their ramifications.

But close cooperation between a number of public agencies now engaged directly or indirectly with the problem will have the effect of creating a single broad-gauge program adequate to help the people bring about most if not all of the necessary changes in our national land-use picture. Not all these agencies are part of the Department of Agriculture: The Indian Service, controlling vast areas of Indian land; the Division of Grazing, with authority over the public range; the General Land Office and the Park Service, are parts of the Depart-

DOWNHILL PLOWING INVITES EROSION

OF THIS IOWA FIELD. SOIL FROM THE UPPER PART OF THE SLOPE IS BURYING CROPS AT THE BOTTOM.

ment of the Interior. The work of the Farm Credit Administration, the Federal Housing Administration and many other governmental organizations bears a certain influence upon land use. All of them, as well as the Agricultural Adjustment Administration, the Bureau of Agricultural Economics, the Farm Security Administration, the Bureau of Public Roads, the Forest Service, the Soil Conservation Service, the Biological Survey and various other agencies of the Department of Agriculture must take a coordinate part in national land-use effort if the scope of that effort is to encompass all lands now ill-used and all the enormous ramifications of the problem. The activities of all these agencies and of various agencies of the states must merge, out on the land, into a line of action in which administrative divisions disappear, objectives coincide and methods harmonize.

Realistically, this is not an easy situation to bring about. But very tangible steps already have been made in the right direction. The relationship between many of these agencies is very close today; programs and objectives are mutually understood; distinctions based on purely administrative lines are rapidly disappearing, and there is every reason to believe that in general the activities of public agencies in the field of land use are better coordinated, more carefully adjusted to one another at the present time than they have ever been.

From the national standpoint, naturally, the Department of Agriculture occupies a predominantly important position in the field of land use.[1] Nearly every phase of the department's activity

[1] "The New Department of Agriculture"; address by M. L. Wilson, Undersecretary of Agriculture, before Texas Agricultural Workers Association, Fort Worth, Texas, January 13, 1939.

CONTOUR FARMING IN SOUTH CAROLINA

WHERE THOUSANDS OF ACRES HAVE BEEN SAFEGUARDED AGAINST EROSION BY TERRACING, STRIP CROPPING AND OTHER OPERATIONS ON THE CONTOUR OF THE LAND.

either directly or indirectly affects land use. The work of the Agricultural Adjustment Administration in the field of economic stabilization and agricultural conservation is a direct influence for better use of the land; the rural rehabilitation program of the Farm Security Administration likewise bears directly on these problems. So also does the work of the Forest Service in the management of national forest holdings and the work of various other departmental agencies in the fields of planning, research and education.

Most directly concerned with land-use problems on the vast bulk of privately owned agricultural land, however, is the Soil Conservation Service, which seeks, through several lines of work, to assist farmers in correcting the physical land practices contributing to land decline. The Service now administers activities involving the conservation of basic soil and water resources, the purchase and improvement of submarginal land areas, the promotion of farm forestry, the treatment of watershed lands for flood control and the development of farm and ranch water facilities in arid and semi-arid regions of the West.

Each of these lines of action is important in itself as a means of land-use readjustment. The adoption of sound soil-conservation practices on a farm or in a watershed suffering from severe erosion usually requires a realignment of present cropping and tillage methods. Frequently, these realignments, when carefully planned, result in a better economic status for the individual farmer and the community. The promotion of forestry as an integral part of the farm economy likewise changes the use of land. The purchase of submarginal areas and their development along lines properly suited to their use obviously affects the land-use pattern in any locality. Adequate facilities for stock water, irrigation and water spreading in the West make it possible to correct abusive grazing practices, improve the range and develop certain areas for the production of crops. In other words, in carrying out each of these several lines of action, patterns of land use actually are altered.

Combined into a single, integrated attack upon the diverse land-use problems of an area or a region, these several action programs constitute a rather well-rounded approach to the correction of the physical ills of the land.

An interesting example of the application of such an integrated program to a given area is the soil conservation demonstration project of the Service in the low-rainfall area of the Wind River Basin, in west-central Wyoming. Heavy overstocking of the range, and poor grazing management had brought about serious depletion of forage over much of the basin, resulting in severe erosion and the waste of water from denuded and eroding lands.

Some 45,000 acres known as the Riverton tract, in the Shoshone Indian reservation, were selected in 1936 for a demonstration of improved land-use possibilities. In this tract, originally well grassed, some 3,335 sheep were then being grazed under a lease management, along with about 500 trespass sheep. The only available water was that of Wind River, which for a short distance forms the extreme northwestern border of the tract. Because of this inadequate distribution of stock water, only about half the area was being utilized for grazing. Much of this was being so severely over-used that the productivity in animal units was steadily declining, along with the land and the forage on the land.

As the basis of developing a practical plan for better use of the area, surveys were made to determine the character and distribution of the soils, the nature and distribution of erosion conditions and potentialities, the present and potential carrying capacity of the range and favorable locations for water development.

With this information, a systematic grazing plan was worked out for the entire area and put into effect. It consisted of the establishment of two grazing routes for 2,000 sheep each, and the timing and regulation of grazing over these routes. Forty-one water holes were established over the tract, and bedgrounds located so that each would be used not more than five consecutive nights on the average. In favorable situations some water-spreading structures were installed, and the area was fenced against trespass stock.

In spite of the increased number of animals using the area, range forage has increased 25 per cent. in carrying capacity, and numerous eroded areas are revegetating in a most encouraging way. The indications are that from time to time additional sheep can now be turned on this tract without unduly checking the improvement in forage.

The results obtained here, moreover, fit nicely into a larger project covering more than a million acres of range and irrigation land in the Wind River Basin. Some portions of this larger area have such little vegetation left that recuperation will be impossible without a reduction in the number of animals using the land. But the Riverton tract, together with other managed areas on which the forage is improving steadily, will relieve the pressure on neighboring lands by taking care of part of the animals now overtaxing them. Still other relief will be derived from the production of supplemental feed by a more conservative and effective use of available irrigation water.

Within the broader pattern of improved land-use for the entire area, still other adjustments in present use have been planned and to a large extent installed. Grazing, for example, has been excluded from certain critical areas from which flash runoff has resulted in serious flood damage to irrigated lands downstream. This control of upland grazing, together with the installation of small retention reservoirs, contouring and water-spreading structures, apparently has resulted already in the material diminution of flood flows.

Also, it should be noted, the project was developed only after a careful study of the economic situation of the land users, both irrigation and livestock operators, to determine how far land-use changes might be carried without overtaxing the economy of the individual rancher or irrigation farmer. These studies have considered the interrelation of the ranch and farm enterprise and indicate, for example, the opportunity for increased production and use of soil-conserving feed crops and the effect of such increases on the total production of sheep by the whole land-use enterprise.

Equally fundamental adjustments in physical land-use practice have also been brought about in farming sections of the humid region through cooperative action by the Soil Conservation Service and farmers. Typical of such realignments are those accomplished in the demonstration project at Lindale, in northeast Texas. This project, it should be pointed out, is representative of the practical possibilities of effecting needed land-use adjustments in a large problem area embracing some 48 million acres: The Interior West-Gulf Coastal Plain in southern Arkansas, northwestern Louisiana and northeastern Texas. This problem area includes much submarginal land, a considerable part of which, although subject to serious erosion under present farming practice, is under cultivation. Approximately 60 per cent. of the land has slopes ranging from 2 to 8 per cent., and is subject to moderate to severe erosion; while about one tenth of the area exceeds 8 per cent. in declivity—a slope generally too steep for cultivation because of susceptibility to very severe soil washing. Thirty-five per cent. of the region is in cultivation, 45 per cent. is forested, 13 per cent. consists of pasture, and 7 per cent. is idle.

ROADS NEED EROSION CONTROL

ESPECIALLY THE UNIMPROVED COUNTRY ROADS ADJACENT TO FARM LAND. THIS ROADSIDE GULLY MAY EAT INTO THE ADJOINING FIELDS.

REFORESTATION IN MISSISSIPPI

OF ERODING FIELDS THAT WERE FORMERLY IN CROPS IS HELPING TO RESTORE THE USEFULNESS OF THE LAND AND PROTECT IT FOR FUTURE GENERATIONS.

ONE OF THE ORIGINAL TERRACED FARMS

EACH FIELD IS IMPORTANT IN SOIL CONSERVATION, FOR THE FIELD IS THE STARTING POINT IN ALL EROSION CONTROL WORK, BE IT FARM, AREA, STATE, REGION OR THE NATION.

In cooperation with land operators in the 23,000-acre watershed comprising the Lindale demonstration project, 80 farms were surveyed to determine the extent and distribution of individual soil types, erosion types and potentialities and the slope classes; as well as to show the location of farm, field and pasture boundaries, fences, drainage ways and other cultural features. With this information, readjustment and conservation plans were worked out individually for each farm, indicating not only the specific needs of each parcel of land, field, pasture, woodlot and idle area, but the measures necessary to effect required readjustments and conservation. The program for each farm was adjusted as nearly as possible to the income requirements of the operator. Careful consideration was given to prospective yields under the rearranged farm system, to the problem of utilizing the products grown under the reorganized plan and to the opportunities for developing supplementary income from properly managed woodlands and game resources.

Some of the major results thus far effected in the project have been: Control of erosion to a degree of effectiveness estimated at 85 to 90 per cent.; reduction of runoff by 25 per cent.; retirement of 33 per cent. of the original cultivated area to the permanent protection of grass, trees or shrubs; reduction of 46 per cent. in the area devoted to soil-impoverishing crops, with an approximately corresponding increase in the acreage of soil-conserving crops; increase of 100 per cent. in the pasture area; improvement of all pastures by contouring, reseeding and other measures; control of all gullies; improvement of all woodlands by thinning, planting and selective cutting; and treatment of all idle land for erosion control.

When the project began 52 per cent. of the area was under cultivation; 21 per cent. was in pasture; 25 per cent. in timber; and 2 per cent. idle. Under the readjustments made thus far, the corresponding percentages of use are: 35 per cent. under cultivation; 41 per cent. in pasture; and 22.4 per cent. in timber. Because of the trend toward livestock development in the area, eroded upland

was for the most part retired to pasture instead of timber. Other areas of eroding upland were retired to a permanent cover of grass, and a comparably productive area of timbered bottom land was brought into cultivation in order that production volume could be maintained. This accounts for the slight reduction in the area devoted to trees.

These changes in land use on the farms participating in the Lindale demonstration project have not only produced definite results in conserving soil and moisture. They have brought tangible benefit in the way of increased financial return on the farm enterprise. A recent survey in the Lindale area showed average annual farm income for the three years 1935 to 1937, inclusive, to be $203 greater on cooperating farms than on those not taking part in the soil conservation program. The cooperating farms had an average annual income of $488 for those years as compared with $285 for the non-cooperating farms. For the two years before the project was started, average annual farm income for all farms in the watershed was $199.

Such local land-use changes as those made in the Riverton range area of Wyoming and at Lindale in the farming section of East Texas must be fitted, of course, into the larger picture of regional adjustment. They are, as a matter of fact, the individual pieces out of which regional and national land-use patterns must be designed.

Rapidly, now, those larger patterns are taking shape. In the semi-arid Southern Great Plains, for example, both the nature and the extent of physical land-use needs have been determined by careful surveys covering nearly 100 million acres.

On the basis of these surveys, proper physical use of the land over this large segment of the Southern Plains will mean an increase of 10 per cent. in the aggregate area devoted to grazing, an increase of 20.7 per cent. in the area devoted to farm pasture and an increase of 22.6 per

CONTOUR CULTIVATION AND CONTOUR DITCHING

PROTECT A VALUABLE PIECE OF LAND IN SOUTHERN CALIFORNIA.

cent. in the acreage of feed crops. These increases will call for a decrease of 30.3 per cent. in the acreage in wheat, 16.6 per cent. of the acreage in cotton, 12.9 per cent. in the acreage of miscellaneous cash crops and 8.1 per cent. in the acreage of corn. These readjustments reflect the need for a general shift from a hazardous cash crop agriculture to a more certain grain and livestock type of farming in the Southern Plains. To make this shift toward a stable agriculture in the Plains, the total area devoted to grazing and farm pasturage must be increased from 57,899,000 acres to 64,399,000 acres, and the total area of cash crops must be decreased from 28,823,000 acres to 21,576,000 acres. The area in feed crops also must be increased from 3,298,000 to 4,045,000 acres.

Extensive alterations of this kind over entire regions call for action along lines broader than the purely physical, of course. The same is equally true of the more local readjustments which together will make up the changed pattern of the region. The correction of physical land ills depends to a very large extent upon the economic and social factors which exercise such a tremendous influence on the way men use the land. The price of farm products may determine whether a man is able or willing to use his land well or badly. Rural roads are a most important factor in determining the feasibility of using land for one purpose as opposed to another. The tenancy situation in any locality has a marked effect on the use of the land, since tenants often lack a true incentive to use the land as it should be used. Complicating factors of this kind could be listed almost indefinitely to indicate the diversity of forces which must be dealt with if better land use in this country is to be a fact.

Nor is the ultimate effect of alterations in land-use practice limited to the physical betterment of the land. It is conceivable, for example, that extensive reorganization of our national land-use pattern will bring about a more even distribution of cash crops and a more regular volume of production, with consequent good effect upon surpluses and farm prices. It has already been demonstrated that through the establishment of good land-use systems on tenant farms it is possible to bring about a higher degree of satisfaction on the part of both tenant and owner and a greater inclination toward long-term leases on both sides.

To cite an interesting illustration in this general connection: In certain localities the filling of stream channels with the products of erosion has caused the formation of marshes and stagnant pools of water along the streams. As a result, malaria has become a menace to the population, where formerly the disease was unknown. Mosquito control by draining the marshes would be only a temporary palliative if erosion were permitted to continue over the uplands. The readjustment of land-use practices to prevent soil erosion on the uplands shedding water into these streams is consequently essential to the public health.

Important also is the effect of land-use changes in one section on conditions in other sections, adjoining or distant. Necessary readjustments in the physical pattern of land use may sometimes call for the removal of people from one section to another. This process, however, can not go beyond the productive capacity of the land available for the transfer of these people. Displacement of the population by retiring the whole of a large area of erodible land from cultivation, for example, will make it necessary to raise the level of productivity in some other area if the displaced people are not to suffer economic and social hardships. On the other hand, if the erodible area should be continued in production without increasing the productive capacity of the non-erodible area, the same kind of economic difficulty would arise with the

LAND RUINED IN ILLINOIS

IS PART OF THE 282 MILLION ACRES IN THE COUNTRY RUINED OR SERIOUSLY IMPOVERISHED BY EROSION. ANOTHER 775 MILLION ACRES HAVE LOST FROM ONE FOURTH TO THREE FOURTHS OF THEIR FERTILE TOP SOIL.

ruin of the former area for agricultural use. The remedy in such situation is to find an economically productive use for the land retired from cultivation, such as the development of a salable wildlife resource or the establishment of a productive orchard on a soil-conserving basis. This, of course, assumes that immediate absorption of displaced farm people into industry or other fields of livelihood will not be very great and that most of them will be forced to continue in agriculture. Possible difficulties of this kind indicate the importance of the relationship of land-use adjustment on one tract of land to the physical welfare of some other tract of land, as well as to the economic and social welfare of those who live on the land or are dependent on its produce.

Ramifications of the land problem thus could be explored almost endlessly. It will be sufficient merely to suggest that they extend into the fields of physics and chemistry, economics and sociology, health and sanitation, education, engineering, and into other fields as well. Obviously, there is no panacea. Whatever is accomplished will be brought about only by coordinating the progress of many programs in many fields toward a common objective.

And while to-day the emphasis is on action by public agencies to assist the actual users of the land, the need for effort along other lines is no less acute. There is need for a thorough understanding of modern techniques on the part of agricultural workers everywhere. We have developed a new kind of land survey, for example—a survey that is actually an inventory of the physical characteristics and condition of the land. It shows the dominant conditions of slope, soil and erosion, as well as the use being made of the land—factors we must know in order to determine the kind of treatment each parcel of land requires if it is to remain permanently in beneficial use.

These new surveys are of great significance to-day, when the matter of land use has come so importantly to the foreground of agricultural action. They constitute the very basis upon which any sound readjustment of land use for the conservation of physical resources and the betterment of human welfare must be made. Agricultural workers everywhere, I hope, will acquaint themselves with the principles used in making these surveys, and will equip themselves to interpret and put to practical use the knowledge made available.

There is need also for research into many of the complex aspects of the problem; into the economics and the sociology of land reform as well as the purely physical problems of readjustment. Likewise, there is need for continuing educational effort so that the gains made by action and research will not be lost as time goes on. People must be taught to think as a matter of course in terms of good land use if what we accomplish now is to be permanently effective.

Summarizing, it would appear that the essential elements of an effective public program of land use are: (1) action to assist people in readjusting physical patterns of use to the physical limitations of the land; (2) action to assist in correcting or mitigating the economic and social forces which tend to impel or encourage physical land abuse; (3) research to implement action with knowledge, and (4) education to establish basic principles of land use firmly in the public mind.

Unless the United States goes ahead vigorously, persistently and speedily to conserve the soil and to make far-reaching adjustments in our complex land economy, national decadence lies ahead. We must continue to capitalize upon experience and to advance through research. From the standpoint of our soil resource alone the need for action is now clear enough. Failure to act has caused the essential ruin of some 280 million acres of farm and grazing land and the injury of 775 million acres more. The average citizen does not yet fully understand the deep significance of this waste, nor realize the hardships it has caused in lowering tens of thousands of land users virtually to the level of pauperized farming with its attendant discouragement and inertia. Nor have we yet fully probed the social and economic implications of this single facet of the problem.

There is no longer a question of the need for coping with these evils. There is no longer a question as to whether we can cope with them. We know that we can. Millions of acres already have been anchored against erosion; new and practical conservation measures are being developed through research and experience on the land; many of our economic and social difficulties are being solved. We are moving constantly ahead, though not yet with sufficient speed.

It should be remembered that to-day's necessity for public action is the outgrowth of yesterday's failure to look more carefully to our land. Hindsight is easy; but foresight during the last century, when our present land-use picture was in the making, would have produced a different result. To-day we are simply retracing our steps across this land in an effort to correct past mistakes in the interest of the future.

EMILE JAVAL—FRENCH SAVANT

CENTENARY, MAY 5, 1939

By Dr. JAMES E. LEBENSOHN

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JAVAL, whose ideal was Benjamin Franklin, was himself of the Franklin type, and emulated his hero in consistent industry and manifold interests. For Javal was not only an oculist, but a legislator, journalist, educational leader, hygienist and social reformer as well.

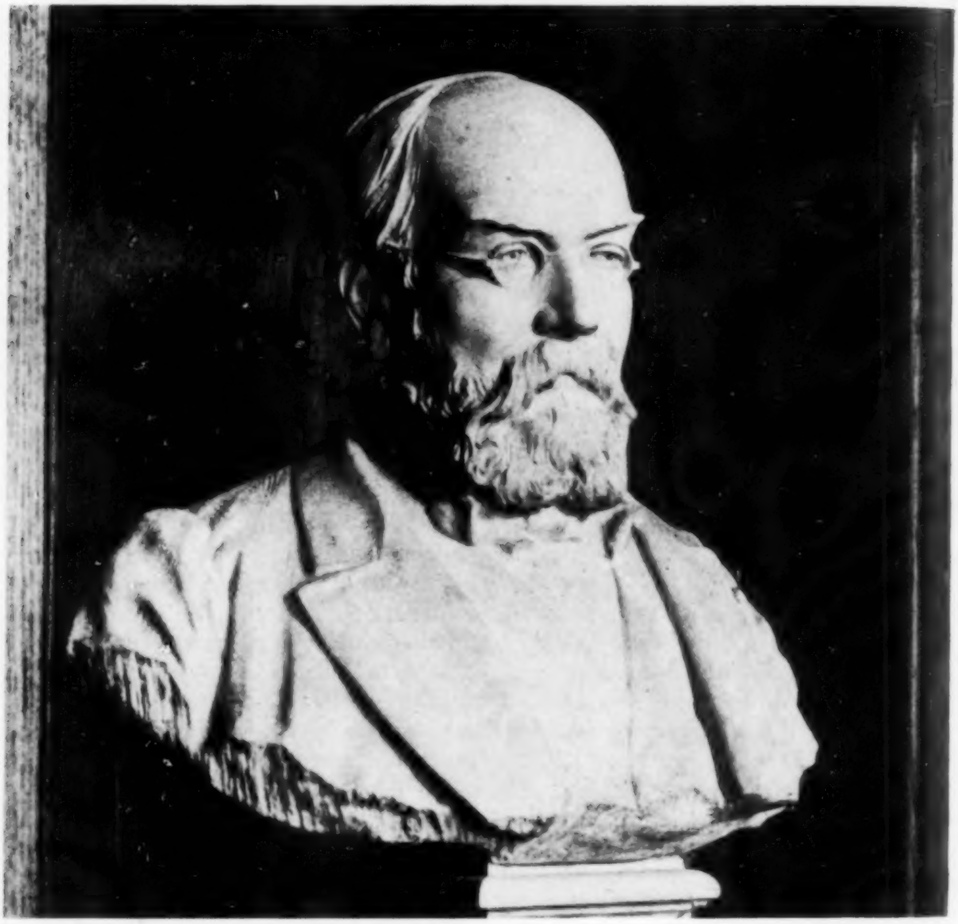
Javal's grandfather, Jacques, was a poor self-educated Alsatian, who peddled for a livelihood from the age of ten, but finally achieved enough means to found a small but successful bank. When this ancestor was born in 1780, four fifths of the 50,000 Jews of France were living in Alsace-Lorraine, having a communal government of their own, but very limited civil rights. Political emancipation first came with the French Revolution and its Declaration of the Rights of Man. In 1806, at the suggestion of Napoleon, the Jews of France changed their oriental patronymics to the type of surname used by the rest of French citizenry. Javal's grandfather inscribed his name Jacob on the register, which, miscopied by the clerk as Javal, became the family name thereafter.

Leopold, Javal's father, finished a careful education by a year in England, where he assimilated English mercantile methods and a love of liberalism. On his return, he joined an expeditionary force to Algiers, where his heroism was awarded the Legion of Honor. Back in mufti, his flair for vast enterprise extended beyond banking to politics, industry, commerce, mines, railroads and agriculture. An associate of the celebrated financier, Jacques Laffitte, and for fifteen years deputy, he maintained a leading position in the world of affairs.

In 1838 Leopold married Augusta de Loemel, the cultivated daughter of a leading banker in Prague. The love for Rousseau that Byron had awakened in the intellectual world was ardently shared by her and her family. Imbued with the idea of progressive education expounded in Rousseau's "Emile," her first child was named after the book and reared by its tenets.

Emile Javal derived from his father the spirit of enterprise, from his mother a devotion to service, from both a keen intellect. Not for him the gay life of a rich man's son; his way was rather that of the practical idealist, zealous in work and simple in tastes. Javal inclined to a scientific career and could not be persuaded to follow his father's footsteps. He originally preferred medicine, but, bowing to family opposition, compromised on mining, and after graduation accepted an engagement in the coal mines controlled by his family. His concern about his sister's squint and his discovery of his own astigmatism reawakened his interest in medicine. His first researches in optics received such encouragement that he abandoned mining and embarked on a medical career, in which he finally established himself as one of the world's foremost authorities on visual hygiene.

After the Franco-Prussian war, in which Javal served as medical officer, he became absorbed in civic issues, education and social reform. He followed his father's lead in politics, and for five years was deputy from his department. He opposed the French construction of the Panama Canal and prophesied disaster for the project. Fearful of depopu-



EMILE JAVAL

lation, he sponsored a law relieving families of seven from all direct taxes. Though the Javal law remained in force but a year, exemption privileges of similar pattern have lately been reconsidered. The influence of his studies on the factors affecting population is reflected also in the novels of Zola. An ardent advocate of adult education, he was with Camille Flammarion among the charter members of an association for the popular diffusion of scientific knowledge, and for many years its president.

Of independent means, Javal's office provided material for private study rather than a source of income. If a patient proved interesting, he would waive the fee and invite him to dinner. Once a month he visited the villages in his canton and gratuitously gave his services to the indigent—a tradition which his Danish assistant, Tscherning, generously continued. A vexatious lawsuit followed a report in which he deflated the advertised claims of some new lenses. An enlightened court fortunately decided for scientific freedom. His young sister, who is still living in Paris, has the distinction of being the first in the world to receive eye exercises in the treatment of squint. Javal's methods achieved a perfect cure, which has persisted to this day. Javal

discovered the eye movements in reading, which laid the basis of an objective analysis of reading ability that has since culminated in instruments for recording eye movements and for training deficient readers.

Javal proposed an original method for teaching reading and writing simultaneously. He emphasized hygienic school construction, proper posture and efficient writing habits. With many educators of that period, he favored vertical penmanship, a beautiful example of which is the hand of Thomas A. Edison. His studies of the effect of variations of light, paper and print on the ease and speed of reading foreshadowed the modern interest in the subject. Ever motivated by humanitarian ideals, he stressed that to facilitate reading and writing is to accelerate communication among men.

In 1897, the excitement of the Dreyfus trial, in which he was keenly interested, precipitated an attack of glaucoma that left him blind for some hours. Now keenly aware of his prospective doom, he prepared his notes for easy accessibility so that whatever happened he could carry on his appointed tasks. Three years later, stark blind, Javal resolved to imitate these brave souls like Euler, Huber, Milton and Fawcett, who had not been deterred by a like fate from magnificent achievement. He invented a writing rack to carry on his correspondence. To Javal, dependence was the chief misery of blindness, and, in a widely circulated book that he wrote at this time, he strove to help the blind to help themselves. He encouraged physical as well as intellectual activity, and himself, by means of a tandem bicycle, continued regularly his favorite exercise.

To his friend, Zamenhof, the oculist of Warsaw, who invented Esperanto, he made various acceptable suggestions to render the language even simpler. He pleaded for the general adoption of this auxiliary language, which would be advantageous to the blind, since it would permit an international use of Braille publications.

Death came on January 20, 1907. Throughout the civilized world scholarly journals and organizations paid homage to the passing of a personage. At the instance of his widow his famous library was transported to suitable quarters in the chief eye clinic of Paris, and a splendid bust by Verlet was presented to grace the reading room. On February 18, 1914, La Bibliotheque Javal was dedicated, a fitting memorial to one of the great scholars in medicine.

"WHENCE COMETH LIFE?"

By Professor WILLIS R. HUNT
LAFAYETTE COLLEGE

PHILOSOPHERS have for ages attempted to explain life and death and to determine where one leaves off and the other begins. Present-day scientists are continuing to investigate this burning question.

Maybe the turning point is where the protein-building catalyst or enzyme first appears. Although it is non-living itself, it no doubt is the precursor of life, that is, it precedes and gives intimation of the coming of life. Possibly the most primitive living unit may be the gene. Have any of you ever seen a gene? No! It can not be seen even by the ultra microscope, but if we are to account for the hereditary behavior of protoplasm we must postulate invisible genes. Genes, as you remember, are the units or atoms of heredity. Other assumptions are that the viruses or bacteriophages may be the most elementary predator or form of life.

It will not be possible to say just where or how life first appears, but some evidence can now be given that the genes and the viruses are at the boundary or border line of life.

Like life the origin of disease has been subject to many theories and much speculation down through the ages. Primitive peoples believed that evil spirits caused disease. In the Middle Ages invisible particles were thought to be the cause. Bacteria were not even seen until the middle of the seventeenth century, and were only proven to be the cause of disease about sixty years ago.

It has been estimated that there are seven hundred and forty-two living agents causing disease in man. Thirty-one are ascribed to a still unseen something, called a virus. There are some forty more viruses causing disease in the lower animals, fowls, insects, fishes and plants. Examples of some virus diseases, to mention a few, are smallpox, rabies, parrot fever, yellow fever, herpes, mumps, measles, infantile paralysis, warts, epidemic influenza and the common cold. Distemper of dogs, fowlpox, carppox, swinepox, jaundice of silkworms and the so-called mosaic diseases of the tobacco, potato and tomato plants are examples of virus diseases in other groups of organisms.

Just what the nature and properties of these "mysterious purveyors of disease" are has been one of medicine's and bacteriology's greatest problems. Up to recently the following three questions had not been answered: (1) Are viruses animate or inanimate? (2) Are they ultramicroscopic entities related to bacteria? (3) Do they represent inanimate chemical principles like catalysts or enzymes, for example, pepsin, an organic enzyme, which stimulates digestive changes in the stomach?

We may define a virus as an infective agent below the size limit of microscopic determination which passes through the finest made filters. They are obligate parasites; no saprophytic forms are known. This is not surprising, is it, since symptoms are the only means of recognizing them? They can not grow and multiply in artificial culture media, but in tissue culture, specific for the virus, the infective active agent has been developed. For immunization viruses are propagated by serial injection of animals. Their behavior is very much like that of a living organism.

An open mind is necessary in regard

to the nature of viruses. One of the smallest known viruses causes foot and mouth disease. It is only large enough to hold a few dozen protein molecules. Is this consistent with life? Would it be consistent if smaller viruses were discovered? Does not their minute size preclude their being alive? It must be remembered that no virus has a characteristic form or the ability to assimilate lifeless matter. Are not form and assimilation two of the chief attributes of life? These questions can not be answered, for we do not know whether there is a definite boundary line between the living and the non-living.

As a virus is dependent on living cells for its development, does not this suggest that they may be derivatives of those cells, an enzyme or catalyst, for example? Catalysts effect a chemical change. The viruses then may have the peculiar property of stimulating healthy normal cells to reproduce more virus substance. The living characteristics that are possessed by a virus are shown only when the virus is associated with living tissue, namely, metabolic assimilation of heterogeneous substances, adaptation and reproduction.

On the other hand, the principles of proof that a particular species of living organism is the cause of a specific disease is stated in Koch's postulates. First, the causal organism must be found in all cases of the disease; secondarily, it must be grown in successive pure cultures outside the body; thirdly, the cultures must be able to reproduce the disease in susceptible laboratory animals or plants, and lastly, the organism must be recovered from the artificially infected host in pure culture. No doubt if viruses were living they would follow these postulates. They do not satisfy number two, namely, cultivation outside the tissue of the host.

Most of the knowledge about viruses has been gained through the study of tobacco mosaic virus. It is the oldest known. It was first described in 1857, but its filterability was not discovered until 1892. It was then discovered that the extracted juice of a tobacco plant affected with mosaic would infect a healthy plant if pricked into its tissues or rubbed onto the leaf hairs, even after it had been filtered through a Chamberland filter.

Tobacco mosaic is the most infectious of all virus diseases. Even when dried and ground into a powder, diseased leaves will still have the property of infectability after months of desiccation. The virus may be extracted by ether, chloroform, carbon tetrachloride, toluene or acetone without any destruction of its infective properties. An infinitive amount of the virus will increase many times over when inoculated into a normal plant.

The symptoms of a diseased plant are the mottling of the leaves due to alternating patches or spots of light green or yellow, and dark green, but under certain conditions the mottling may be masked.

In 1921 a new concept of the nature of the tobacco mosaic was suggested. The substance of this concept was that it was a product of the host cell, a gene, perhaps, that has revolted from the shackles of coordination, and having the property of reproduction, continues to produce disease only in the living plant cells.

As tobacco mosaic virus is the most outstanding in having properties which are easily worked with, as stated above, and as it is typical and representative of all viruses it has been experimented with extensively. Countless numbers of tobacco plants have been grown and infected artificially. The diseased plants after a certain time were ground up, pressed and the tobacco juice containing the virus extracted. Protoplasm, in general, contains proteins, fats and carbohydrates. Certain enzymes are protein splitters or digesters. Proteolytic pepsin,

as noted before, is an organic protein digester. This enzyme was added to some of the plant juices in a test-tube and kept under suitable conditions to see if it would act on the virus. After a certain length of time a small amount of the solution was rubbed on the leaves of some healthy plants. No infection resulted after repeated tests, as the protein causing the disease had been digested. Pepsin is specific in its action; it will not act on fats, carbohydrates, hydrocarbons or salts. Therefore a sound conclusion that the virus is protein in nature can be made.

Certain chemicals such as ammonium sulfate or dilute alcohol will precipitate proteins. They were added to some of the diseased tobacco juice to which pepsin had not been added. A solid precipitate was thrown down. A bit of the supernatant fluid was rubbed on healthy leaves. No infection resulted. A different picture was represented when a neutral liquid, as water, was added to the precipitate and it was dissolved and then rubbed on normal leaves. Diseased plants resulted. These two experiments proved without doubt that the infective agent resided in the protein molecules.

To further prove the nature of the virus, the precipitate was again dissolved in a neutral liquid and ammonium sulfate compound was added. Crystals were formed from the solution. These crystals were refined by ten successive fractionations and recrystallizations. By this technique all impurities as well as all living matter was separated out. Why do we say that all living matter was eliminated? Because no protoplasm is known to possess the property of crystallization. Did you ever see a crystalline gonococcus, amoeba or a "crystalline chicken" either in a coop or walking down Fifth Avenue on Easter Sunday or any other day for that matter?

Now if these crystals infect healthy plants far-reaching results can be expected in regard to their nature. A few crystals were dissolved in a neutral liquid a hundred million or more times their bulk. Healthy leaves were again inoculated, and all the symptoms of the mosaic virus disease resulted. The conclusion of this experiment was that the crystals were made of many protein molecules, and each molecule of this cluster of crystals is a single virus of the tobacco mosaic disease.

Chemical analysis proves that the virus molecule is very large, a macro-molecule. Carbon, nitrogen, hydrogen and chlorine have been found in these molecules, but how many atoms of each and their arrangement is not known. That is, there is no chemical formula for a virus as yet.

In addition to the above chemical methods the ultracentrifuge clarifies the evidence as to the nature of these macromolecules. The ultracentrifuge gives us a knowledge of the protein itself, degree of purity and the extent of its concentration at each step in its isolation. A pure protein in true solution is made up of molecules of the same size and shape, and it will sediment at a constant rate in an intense uniform centrifugal field. The heavier the molecule the greater the rate of sedimentation. The sedimentary boundaries that arise between protein and solvent is determined by photographing. The molecular weight of the mosaic virus was found to be seventeen million times as heavy as a hydrogen atom. We may now think of this virus as a "macromolecule" with a structure that must consist of hundreds of thousands of atoms, and may be more.

Is this virus living or non-living? Remember that it can't be cultivated in a test-tube, but bacteria which seem to be their nearest living relatives can assimilate, grow and reproduce in this non-living medium. Yet the only way this virus can grow and reproduce itself is when it is stimulated by contact with the tobacco plant tissues. An infinitesi-

mal particle will infect a normal plant, and in a few days the whole tobacco crop will be diseased and producing the original amount of virus a million times over. Is not this ability to propagate itself a property of living things?

Maybe this virus lives a Dr. Jekyll and Mr. Hyde sort of life, a dual personality, alive in certain phases of its existence and raising havoc in a tobacco field, and under another set of conditions not alive and harmless as sterile water. It is alive and has the attributes of living things when in the presence of tobacco protoplasm and non-living in other environments.

This crystalline protein causing tobacco mosaic has many points in common with a gene. They are about the same size. They both reproduce under certain specific conditions and can refrain from reproducing for long periods of time without losing this property when favorable conditions exist. Quite a human characteristic! This characteristic can be illustrated by the inactiveness of the genes in an unfertilized egg of a human, thank goodness, or in the resting seed of a daisy or the inactiveness of a virus in dried tobacco leaves or in a spittoon.

Furthermore, the gene and the virus have another similarity in common, namely, that of unstability. A gene can and does mutate. The virus may suddenly change or mutate to a "masked" form showing no mottling, and this form in turn change into another strain showing a yellow mottling in place of the original light green. The size of the virus molecule increases with these mutations.

The gene to be effective must associate with other genes. It doesn't work alone. A virus must be in contact with living protoplasm to be effective. Is this single gene or virus molecule alive? The evidence points to the answer, "No."

Azotobacter is a heterotrophic genus of nitrogen-fixing bacteria which is able to use free uncombined nitrogen of the atmosphere. It grows in well-aerated arable soils; it is a strict aerobe. Azotobacter is about the size of a yeast plant cell. It obtains its energy from the oxidation of carbohydrates in the soil, and takes in free nitrogen from the air for the synthesis of protoplasm. Is not this a property of living organisms?

Some Russian chemists recently carried out a very interesting experiment. A culture of these bacteria were grown. They were then crushed and their juices filtered off. There were no traces of the cells present. To this filtrate a carbohydrate was added, oxygen and nitrogen gas were bubbled through the liquid. This filtrate then produced ammonia like the culture of living bacteria in the flask of nutrient broth. What was producing the same chemical reaction in the lifeless fluid that was carried out by the living bacteria in their metabolic activities? Enzymes were no doubt responsible in both chemical reactions. More ammonia was produced in the test-tube than in the living culture. May not this be explained by the fact that *in vitro* the enzymes were not shackled with the extra burden of producing the characteristics of life?

We are still at the starting line of life, and much more work will of necessity have to be done before we can answer all the questions in regard to the nature of genes and viruses. Can't we make the assumption that the organization of matter is just a step in the production of life? Isn't it a matter of complexity of organization from these simple bacteria through the protozoa and metazoa to ourselves? Doesn't matter itself start from protons, neutrons and electrons, combine to form atoms, and atoms to form molecules, and aggregates of molecules to form crystals?

Is not the phenomenon which we call life the chief difference between these organizations? Somewhere and somehow in the general mixup in the formation

of carbohydrates, fats and proteins from simpler substances, the catalyst or enzyme makes its appearance. The first catalysts may make amino acids, other catalysts simple proteins from these amines, and then other catalysts more complex proteins. The association of many proteins to form large molecules may be the first genes. These genes arranged themselves in strings to form chromosomes, specialization developed and the attributes of life were exhibited.

From the evidence which has been given there seem to be two possibilities as to where life first appears, either as macro-molecules in the form of genes or macro-molecules as viruses. Both genes and viruses fit in part into the Mechanistic and the Vitalistic theories of life. But whatever the first form of life was, we may well assume that the enzyme is the precursor of life, and whenever it finds itself in a favorable environment it becomes active and life begins.

EMINENT MEN

By Professor MAPHEUS SMITH
UNIVERSITY OF KANSAS

THE present review sums up in the briefest possible form what has already been thought and studied about eminent men as a class, and what we desire to know, and indicates the significant gaps in our knowledge. It is presented because of a belief that the understanding of historical events and the solution of social problems will be advanced as much by the positive approach (the study of leaders and eminent men) as by the negative (the study of criminals, the unemployed and the mentally deficient); and because of a desire that knowledge of eminent men and leadership will eventually be as full as our knowledge of criminals and crime. The treatment does not emphasize any point of view to the exclusion of others, except that it is a *generalized* treatment of an entire class rather than of specific individuals.

"Eminence" refers to superior position. The eminent man is one whose superior position rests upon a degree of recognition by other men rather than upon power. Genius and eminence are essentially different, although most men of genius are, or will be, eminent and many eminent men have exhibited genius. Every man of genius has very superior ability, especially in inventiveness and originality, while every eminent man has obtained a superior degree of formal social recognition. Different from each is the leader, who is the stimulus-giver in any situation resulting in the expressed integration of originally divergent tendencies of a number of people. For practical purposes, such as the present study, eminent persons are those who have obtained recognition in historical encyclopedias, or in lists of prominent contemporaries, or who have been awarded national or international prizes and honors for actual accomplishments. The study of eminent men is significant because eminent men are the *élite*, the social type of top-ranking men who are recognized as the most important of their times and of history, who have led in social change and in social organization and who serve as models for subsequent generations.

THE SOCIAL RÔLE OF THE EMINENT MAN

Because so little consideration has been given to the effect of the eminent man upon history, the significance of eminent men may be related to the individualistic or "great man" conception of history and

human society. Extreme theories of the social significance of great men are of two sorts: first, the great man is the essential mover in historical and social events; second, the great man is only one element in historical and social change. There are also numerous combinations of these views. The chief early conceptions of the great man as the essential mover in social events were the court historiographic, the clerico-ecclesiastical and bourgeois conceptions.[1] The causes of development of these conceptions are a combination of inadequate information and restricted personal and social background on the part of the theorist with the lack of ability to dissociate himself from his background. The chief emphases of the opposite theory are: the great man's ideas are chiefly borrowed, the great man's position in his time and in history is the result of circumstances over which he has no control, and the great man merely personifies a process over which he has no control. The first of the extreme views is too microscopic, the second too telescopic, each is too restrictive and uncritical, and only a combination view can be satisfactorily realistic. The problem really needs to be stated in another way: the important thing is the social rôle and not the individual. But the rôle is necessary, which is to say that individuals who do certain types of things (such as lead and originate) are necessary, but they are limited by social conditions which they can only partially control. Because both individuals and social conditions are necessary in any explanation of social fact it is impossible to say which is the more important of the two factors.

Most of what has been said about the great man applies to the eminent man. But all eminent men are not dynamic figures; all do not contribute to social change. Many are merely figureheads. Eminence is often but not always the result of recognition for dynamic contributions. It provides opportunities for such contributions but does not insure them.

[1] F. Oppenheimer, "History and Sociology," Chapter xix in W. F. Ogburn and A. Goldenweiser (editors), "The Social Sciences and Their Interrelations," Boston, 1927, p. 221.

Climatic and Physiographic Factors in Eminence

A review of the relationship of climate to the place of birth of prominent persons in all the European nations, in China and in the United States and of the relationship of climate to the distribution of patentees of inventions over the world shows that there is only a loose association between climate and production and place of residence of ascendant persons. The same is true of the relationship of air pressure, topography, soil and volcanic character of the land to the birthplace of prominent persons. Likewise, temperature and other meteorological variations are only very loosely associated with invention and other forms of creative activity. The most satisfactory conclusion at present is that geographic and climatic factors are only indirect in their influence and set only the most extensive limits of variation, within which other factors account for the distribution of place of birth and residence of prominent persons.

Anthropometry of Eminent Men

Examination of the scanty evidence available suggests the tentative conclusion that eminent men and leaders as a class possess a superior degree of height and weight; superior weight-height ratio; a superior degree of head size, cranial capacity and brain weight; superior size of cerebral areas in ratio to body weight, deeply set eyes, orgnathism, large nose and deep and powerful voice. The evidence on the relationship between social recognition and each of the following characteristics is not consistent enough for even tentative conclusions: cephalic index, distance between eyes, size of eyes, lines of lips, thickness of lips, anomalies in facial and cranial contours and pigmentation. "Handsomeness of appear-

ance" had not been investigated enough to be included in the summary. The items of the former group may be of some significance either by adding to the physical or mental powers of the ascendant individual or by adding to his impressiveness over those who follow him or give him social recognition. However, there is no perfect assurance that these characteristics contribute anything to the eminent man. It is possible that they are merely associated with a superior type and are indices of all-round superiority without adding anything important. The correct answer to this question is unknown, but the total importance of all the anthropometric characteristics appears not to be very great.

Fundamental Biological Factors

Because leadership and achievement always involve activity on the part of the leader and achiever, some factor accounting for the excess of activity must be associated with leadership, achievement and eminence. Since there are prominent physical aspects of all activity, superior energy, endurance, strength, health and other positive or dynamic factors are associated with leadership, while disease or inferior energy, endurance, strength and health are rarely associated with personal ascendancy. On the rare occasions when "negative" biological conditions are associated with leadership or achievement, the achievement is intellectual or mental rather than physical, because mental activities make relatively little drain on physical resources. Studies in biochemistry have shed considerable light on the dynamic agents in the living organism which undoubtedly underlie all explanations of action; but little relationship has been discovered between biochemical facts and leadership. Even should important relationships be discovered, the biochemical facts would operate only through actions that must be described in other than biochemical terms if leadership and achievement are to be accounted for.

General Intellectual Status

There is evidence from a number of sources that leaders have superior intelligence and that as a class they surpass followers as a class. It is also true that intelligence is commonly considered to be an attribute of all sorts of leaders. The average intelligence of eminent men in childhood is far above that of the general population, and this is especially true of philosophers, writers, revolutionary statesmen and scientists. However, degree of eminence is very slightly related to estimated intelligence, and intellectual status is not a satisfactory basis for the prediction of leadership, achievement or eminence. General intelligence is a characteristic which is a powerful aid to leadership, achievement and eminence, if other conditions are satisfactory.

Special Abilities

The existence of special musical, graphic, calculating and mechanical abilities which are not learned and which are not always associated with general intelligence is now beyond question. At least a superior degree of musical and graphic talent is necessary for success in music and the graphic arts, and most if not all of the most eminent persons in these fields have possessed a high degree of the talents. The other special abilities are not so clearly related to eminence. Speed of action is not a true special talent, but it is not entirely learned. It is very likely a factor in initiative and therefore is especially significant for leadership, and to some extent for all social ascendancy arising from unformalized and uninstitutionalized social situations.

Originality

Originality in its broadest sense is the ability to bring into existence some idea or material construct that never before

existed in the same form. Two types can be distinguished, individual and social, the former being common, the latter very rare. Social originality is much more common in the man of genius than in the average of talented persons, and individual originality of the man of genius may also surpass that of other men. But there are no known differences between the process of originating in the men of genius and in others. There are two methods of accounting for original actions—reasoning to new combinations of elements and intuition. Each of these can be explained in neuro-psychological terms as the development of action along neural paths, and the translation of this action into consciousness which is a necessary step before the action can be communicated to others. It is argued that some nervous and symbolic systems are more complex, sensitive and unstable than others, and that people possessing such organisms are likely to be men of genius. Originality is partly associated with general intelligence and with memory, but is quite different from each. Originality is a prerequisite of leadership and eminence in all artistic fields and is necessary in almost all intellectual fields. In practical life and in executive leadership it is not so important, but a limited degree of it is an advantage.

Negative Psychological Factors

Under this heading are included the relationships of mental deficiency, mental diseases, epilepsy and psychopathic personality (considered generally to be handicapping or "negative" psychological conditions) to leadership and eminence. Except in very restricted situations, mental deficiency is certainly a handicap. On the other hand, definite mental disease is not uncommon among men of outstanding genius, and it may even be of importance in increasing prestige, but psychosis very rarely is known to contribute anything to achievement. Epilepsy also is not unknown in the eminent, but it is of small significance in accounting for achievement or recognition. Psychopathic personality, which is a very indefinite conception, is often claimed to be associated with originality and with eminence. Psychopathic behavior does not seem to be closely associated with leadership, but rather with originality and through that with prestige and even eminence. But until the term "psychopathic personality" is more carefully defined, its use is extremely likely to lead to circular reasoning.

Personal Behavior Traits

The social behavior characteristics most definitely associated with eminence are trustworthiness, conscientiousness, desire to excel, desire to dominate, self-confidence, self-esteem, quickness of apprehension, profoundness of apprehension, originality, extent of mental activity, forcefulness, capacity to work with distant objects in view, strength of will or perseverance. Extreme depression, liability to anger, unconventionality and desire for admiration are not uncommonly associated with eminence. There are some variations in the traits from one field of eminence to another, and considerable variation between traits associated with leadership and those associated with eminence. The traits of most importance for all types of personal ascendancy are enthusiasm, self-control, knowledge, originality, dependability and consistency, morality, sincerity, industry, devotion to an external cause, perseverance, depth of understanding of social behavior, singleness of purpose, foresight, flexibility and versatility, tact, sense of humor, speed of action, initiative, decisiveness, friendliness and sympathy, aloofness, self-confidence, confidence in others, skill and ambition. However, the most important thing about the social behavior traits of the leader and eminent men is that they always relate to some specific situation,

and in that situation relative superiority to the follower and the masses is the universal trait.

Age Factors in Leadership and Eminence

Age is positively associated with leadership and influence in all periods of human life, except in extreme old age. Leaders have a somewhat greater average age than their followers, even where the activity is limited to a relatively small age range. The means of personal influence also undergo changes from infancy to adulthood. Some achievements of outstanding men of genius are often made very early and most men of genius continue to make achievements until advanced in age. There are striking variations from one field to another. Recognition lags behind achievement, but never so far that many men first become eminent at an advanced age. The necessity of achievement and the passage of time between achievement and recognition go far to account for the greater average age and longevity of eminent men as a class.

Developmental Aspects of Personal Ascendancy

In childhood and youth persons who are to become eminent exhibit many physical, mental and social characteristics similar to those of eminent persons, and in most cases the man clearly is foreshadowed in the child and youth. Children who combine precocity and well-rounded superiority tend to develop into leaders and later into socially prominent persons. Irregular development is more rarely associated with leadership than is consistent precocity, while consistent retardation is opposed to individual ascendancy and is conducive to consistent followership. Men of genius often exhibit "childlike" traits, but these are generally one aspect of unconventionality, which in intellectual and artistic fields is often recognized as originality. The tendency to be a leader shows stages of development as clearly as do other aspects of the individual's history.

Sex and Eminence

Far fewer women than men attain social prominence. This is especially true in law, business, science, religion, public office, journalism and medicine, but even in the field of education their standing is little better. In acting and dancing women equal or surpass men; and in authorship and social welfare they compare favorably with men. One widely accepted explanation is sex-linked variability in the male, but this is not apparent at birth, and in childhood and youth these factors are not of very great significance. In youth sex differences are more pronounced and there may be a tendency for the intelligence of the female sex to decline as age increases. There is, however, no evidence that the decline is sufficient to account for the ultimate sex differences in the production of eminent persons. Aside from a possible sex-linkage with decline in intelligence, there are several biological differences that affect social recognition, such as less physical strength, smaller size, less endurance, less impressive voice and handicaps accompanying the function of reproduction. Other factors that may prove to rest on hereditary foundations are the non-competitiveness and lack of dynamic impulse of girls and greater emotional instability. However, social pressure combined with difference in social rôle can easily account for most of the difference in eminence, and these factors even may account for some of the so-called inherited differences, such as aggressiveness in the male.

Race and Eminence

Each of the main races of mankind has made some contribution to the groups of world-historical eminent persons and contemporary notable persons. There is no absolute race difference in inventive-

ness, but there are striking differences in relative contribution. The white race stands supreme, the yellow race second, the black race third. The American Indian has contributed but few persons of prominence. Pure-blood Negroes have much less chance of obtaining formal social recognition than mulattoes. Some of the difference may be due to biological factors, but the precise amount is still unknown, since certain social conditions confuse the issue. While not a strictly racial group, the Jews have been mentioned as the most superior group of mankind, especially in intellectual, commercial, artistic and scientific pursuits. The same is true of the Anglo-Saxons, also very superior, as were the ancient Greeks. But in the case of these groups there is no unquestioned evidence that the cause of superiority is racial and not social.

Civilization and Eminence

The culture of modern Europe and its colonies has produced far more of the eminent persons of history than any other of the great cultures. The Graeco-Roman culture ranks second, and all others lag far behind. The ethnocentrism of history-writing, which can not be wholly escaped, is the dominant factor accounting for the rank of the culture in this particular.

National Origins of Eminent Men

Without regard to population, the most favorable world-historical loci of world-historical eminent persons, according to the point of view of the present historical period, which is the only age of modern significance, have been, in order, the British Isles, France, Germany, Italy, Ancient Rome, Ancient Greece, the United States, Spain, the Netherlands, Sweden, Russia, Denmark and Switzerland. The order varies in several fields of eminence. Information is available only with regard to European countries from 1600 to the present time when the population of the various countries is taken into consideration. In this item Scotland and England lead, followed in order by Iceland, Denmark, the Netherlands, France, Switzerland, Ireland and Germany. Northern and western European countries have advantages over southern and eastern countries and small ones over large ones. The rank positions of all countries are, however, very imperfectly known because of the limited study on this question and the peculiar difficulties of historical research on population groups.

For contemporary prominent persons the most favorable locus, as determined by number of prominent residents per unit of population, is Denmark, followed in order by Norway, Sweden, Switzerland, the British Isles, Finland, the Netherlands, Hungary, Austria, France and Belgium, Germany and the United States and Canada. When only persons of greatest eminence, winners of Nobel Prize awards from 1900 to 1937, are included, the order changes to the following: Switzerland, Denmark, Norway, Sweden, Austria, the Netherlands, Germany, Belgium, the British Isles, France, the United States and Canada, Hungary and Italy. The advantage of the northern and western and of the smaller countries is again obvious.

Regional Origins of Eminent Men

Every country has its more and less favorable regions of birth and residence of eminent men. These have been studied in detail for France, Italy, Germany, the British Isles, China and the United States. The distribution in the United States is most closely correlated with relatively cool and dry climate, a population possessing a relatively small proportion of people inferior either biologically or socially, a high average intelligence test performance, a relatively large proportion of persons of

superior intellectual status, superior health and health facilities, and a large urban population. To these items may be added large per capita income; relatively large ratio of per capita savings bank deposits to per capita income; superior economic efficiency; superior rank in consensus of wealth; large state government expenditures for education, hospitals, roads, etc.; superior condition of the state school system; large per capita circulation of both widely read and "highbrow" magazines; small proportion of Methodists and Baptists in church membership; small ratio between population and number of prisoners committed to federal prisons and to the state prisons of New York and California; general condition of superior education and culture; general condition of superior public order; general condition of superior morality and respect for fundamental law; and general condition of superiority in wealth, education and general culture, health, public order and respect for fundamental law and morality. Limited evidence suggests that the United States is not unique in the association of eminence with these conditions.

Rural and Urban Distribution

Urban areas are more favorable as places of birth and rearing and far more favorable as places of education and residence of prominent persons than are rural areas. Only agricultural leaders and master farmers surpass the general population in percentage born and reared in rural areas, and only master farmers surpass the general population in proportion residing in rural areas. Women agricultural leaders surpass the general population in percentage born in urban areas. When the crude differentiation into rural and urban areas is analyzed further the most favorable place of birth for eminence proves to be suburbs of large cities, followed in order by villages and small cities, cities of medium size, large cities and farms. Large cities are outstanding as places of residence of the prominent, followed in order by smallest urban communities, medium sized cities and rural areas. It also appears that small state university cities outstrip all others as favorable places of birth and residence for social prominence, followed in turn by capital cities of states, large metropolitan centers and metropolitan manufacturing centers. The explanation lies in environmental factors, such as the handicaps of rural residence, farm occupations and low economic status; the greater access of urban dwellers to the determiners of prominence; and the fact that the urban point of view dominates in determining what is socially important.

Social Position and Eminence

The economic status of eminent persons is certainly much higher than that of the general population and is one of the most clearcut correlates of eminence known. The association is both due to the fact that high economic status carries prestige and power and also to the fact that acquisition of social influence tends to be followed by opportunities for economic improvement.

The occupational status of contemporary and historical eminent persons as a class is very superior. The occupational and industrial groups providing the greatest opportunities for contemporary prominence are, in order, literature, college and university teaching, painting and sculpture, the other professions, architecture, acting, music, business, manufacturing and agriculture. Chances for eminence of persons in these occupations correspond closely with the social prestige of the occupations. The occupations of the parents of prominent persons are also superior. As a consequence, occupational transmission is somewhat greater for prominent persons than for the general population.

Mobility and Stability of the Eminent Person

Ecological or spatial mobility of a person is a handicap to eminence unless the person is moving toward a more favorable opportunity for eminence; and psychological mobility is always a handicap to leadership and eminence, at least temporarily preventing leadership and recognition and destroying that which already exists. Movement upward in social status is an aid to total influence if it is a movement toward greater opportunities for eminence, but again mobility, which breaks more psychological ties than it makes, is always a handicap to leadership and eminence. The importance of maintaining psychological ties is shown by the relatively few changes in occupation of the most outstanding persons. Rise to a position of eminence requires considerable time, and frequent changes of occupation usually reduce the chance of rising. However, mobility is of advantage to those whose influence it does not reduce, since it gives them broader knowledge and insight. The person in intellectual and artistic pursuits is especially likely to gain by travel and new experience.

Home and Family Factors

The marital status of the eminent man is not greatly different from that of the professional classes, but a much larger proportion of eminent women are single than is true of the total population. The most illustrious men are similar in this respect to prominent women. The average age at marriage of prominent men is considerably greater than that for the general population, the proportion of childless marriages is larger, and the average fecundity is smaller than that of the general population, but not widely different from that of the population of the same social class. The oldest child has more chance of being eminent than the child of any other order of birth. It is not entirely clear whether or not the youngest child has more chance for eminence than the intermediate children. The parents are older at the time of birth of the child who becomes an eminent person than is true of the parents of an average child. There is a positive relationship between age of parents at the child's birth and degree of eminence. Home and family social relationship factors of especial significance are normally constituted homes; encouragement, stimulation and patient teaching by parents; harmonious marriage relationships; and harmonious relationships with children.

Association Factors in Eminence

A relative degree of both association and solitude are required by all persons, and the ascendant individual is no exception. But intellectual and artistic leaders require a greater proportion of solitude than do executive and other leader types. Associates of eminent men and leaders tend to be leaders and prominent people. The community leader's efforts are given to many organizations rather than to one or two, and the number of organizations with which he is associated tends to surpass the number for the average person.

Education and Eminence

The educational background of eminent persons is superior to that of other classes and always has been. Education is also becoming increasingly associated with eminence. The association is closer for professional fields and less close for the artistic and executive fields. The responses of eminent persons to scholastic training have also been superior to those of other classes. Technical education, however, is not clearly required for eminence, and indeed it has been claimed that education does not "cause" eminence or leadership, but that it selects people of high ability, and that people lead and attain eminence because of the high ability.

Religion and Eminence

The religious affiliations of eminent persons are incompletely known, but it seems clear that a larger proportion of the more selective religious groups are eminent men than is true of the other religious groups. Children of clergymen have a greater chance of eminence than children of any other large occupational group. However, the religious background is more selective of than it is contributive to, eminence and leadership, in this respect resembling the educational background.

Synthesis of Factors in Eminence—Hereditary and Environmental Factors

Most of the facts accounting for eminent men can be interpreted in terms of either hereditary or environmental factors, but the man at the time of achievement is so clearly a product of original stuff and of experience that only a theory based on organic interrelation of hereditary and environmental factors is justified.

Synthesis of Factors in Eminence—A Sociological Interpretation

The only completely satisfactory explanation of eminence must be complex, coordinated of the characteristics of the eminent man, of those people whose recognition makes him eminent and of the conditions surrounding both the eminent man and his electors. In addition, there must be added the dynamic element of interaction which may be called the process of election. The characteristics of the eminent man are those that have already been mentioned. Electors are of two sorts: first, experts and critics in every field of endeavor, and historians who cover all fields; and second, the masses. The evaluation of each class of electors is due to the influence of the eminent man's characteristics, of his achievement, of the general cultural conditions—including others who place a superior evaluation on the man and his accomplishments; and to special means of influencing others in his behalf, such as publicity, propaganda and the claque. The process of election is distinguished by a great deal of discussion and rationalization and has a definite developmental history. There is great variability in the total conditions accounting for each eminent person, and it is hopeless to expect this fact ever to change in a society based upon the present plastic individual organism and the social organization of the leading countries of the world.

The Future of Eminence

The social conditions that help to produce social recognition and eminence show no signs of waning. Also, the native ability of the race is neither appreciably increasing nor decreasing. So we may expect that eminent men of the same type as the present and past will continue to be produced as long as the individual has any social value. The mass point of view may replace the tendency to put a special value on the individual, but until the personal nature of human nature changes it is unlikely that men will cease formally to recognize superiority in their fellows.

BOOKS ON SCIENCE FOR LAYMEN

THIS EARTH OF OURS[1]

THIS book is almost all that its publisher claims for it. It is well written for its particular audience and is unusually well illustrated both by photographs and diagrams which are equally expository. I can not think of a better traveling companion for the non-professional man who has any interest at all in his environment and it even might intrigue a non-interested person into a cumulating interest.

It discusses in easily understandable language the origin of the earth and its early history; how scientists compute its age; the various kinds of rocks of which it is composed; volcanoes, geysers and springs; the formation of mountains and other natural wonders; as well as such topics as the origin of life and the panorama of life that has passed across the stage during the earth's long history.

It is written, it seems to me, with more of a feel for the physical than for the organic side of geology, but the latter topics are good as far as they go. There is one blemish, which is that it appears to have been written for a particular kind of layman, namely, the Catholic layman. While I do not take exception to any specific statement, I certainly am not in the least interested in the official position of the Catholic Church with respect to any biological or geological hypothesis, and think such statements have no place in a book with the avowed purpose of this book.

One need not consider publishers' blurbs too seriously, but when we are told the author's "whole life's work has been dedicated to geology" one expects a reasonable maturity, at least some loss of hair or wrinkled brow or whiskers, and it is somewhat disconcerting to find that the author is in his early forties.

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[1] *This Earth of Ours.* By Victor T. Allen. Illustrated. xvii + 364 pp. $3.50. Bruce Publishing Company.

PLANTS AND ANIMALS OF THE DESERT[1]

POPULAR interest in natural features of the desert has grown rapidly as the southwestern states have become more and more accessible to motor travel. Agencies for guidance of the interest have been few. In an ample book entiled "Deserts" Gayle Pickwell has supplied an attractive guide to desert plant and animal life, popular in style and reliable in its facts. The essential geographical and biological features of deserts are briefly described and attention is drawn to the small desert-like areas which occur far outside the continental deserts. Much more could have been said about the physical conditions, and the author's previous book "Weather" is an assurance that he could have added a long and interesting chapter on the climatic features of desert.

The treatment of desert life is based almost entirely on the Colorado and Mojave Deserts of California. Southwestern Arizona is designated as a part of the Sonoran Desert. There are very few respects in which the areas on the two sides of the Colorado River differ, and the Colorado Desert is essentially a subdivision of the Sonoran Desert.

A few paragraphs are devoted to each of the outstanding plants and animals. The examples are well selected and the comment on them will answer just the questions that the inquiring mind is apt to raise. Many ardent devotees of the desert will find the discussions far too

[1] *Deserts.* By Gayle Pickwell. xvi + 174 pp. Octavo. $3.50. Whittlesey House, McGraw-Hill Book Company.

brief. The sumptuous illustrations are the commanding feature of the book and do as much as the text to describe land forms, animals and plants. The pictures of the reptiles are particularly fine. Those of the scorpion and centipede have been enlarged almost to the scale of the popular dread of them. Some of the plants have been enlarged more than is necessary for the best effect.

It is obvious that Professor Pickwell is a keen and patient observer. He knows the desert well, and betrays his admiration for the markings of the rattlesnake, the flowers of the desert lily and the ripples on the dunes. His statements of fact are authentic, without the exaggeration so common in popular books on natural history, and give the reader the impression that he knows a great deal more than he is telling—as an author should. The ocotillo (*Fouquieria*) is not the only member of its family, although it is the only one in the United States. Ocotillo does not mean "little pine" but "little torch," although the torch pine of Mexico is commonly called "ocote." There are few such mistakes. The book is a fine example of the better sort of natural history, and helps to mark the advance that a more exacting audience now demands.

FORREST SHREVE

THE STORY OF A CENTURY[1]

THIS encyclopedic work is the second volume of the author's History of Science, the first volume having covered under a similar title the sixteenth and seventeenth centuries. If the author carries out his evident intention to continue his work with a corresponding history of the nineteenth century, it will be interesting to find how many volumes will be required.

Before undertaking such a monumental work as the history of the science of the eighteenth century, an author must adopt some systematic approach to the task, for otherwise the reader would become lost in the endless details of, and interrelations among, scientific and technological advances. For fairly obvious reasons, Professor Wolf has not followed the chronological order of events. Instead, he discusses the different phases of his subject in the order of "diminishing generality (or abstraction), beginning with mathematics and ending with the biological sciences." Without contending that he has not chosen wisely, it may be noted that psychologists often point out that we normally proceed from the particular to the general and from the concrete to the abstract. If an author should discuss astronomy, "in the order of diminishing generality," he would start with a mathematical theory of the universe and end with descriptions of the planets and methods of observing them. To present the history of science during the eighteenth century is a formidable task. The science of this century had its roots in earlier periods; it developed with unparalleled diversity and speed; and it is to be interpreted in the light of nearly a century and a half of later developments.

In conformity with his general plan of beginning with the most general and abstract subjects, Professor Wolf treats in order mathematics, mechanics, astronomy, astronomical instruments, marine instruments, light, sound, heat, electricity, etc., through a total of thirty-two chapters, the last two of which are on philosophy. It will be at once evident that the arrangement is not without difficulties, for many men contributed to several of the fields into which Professor Wolf divided the history of science. For example, Gauss made last-

[1] *A History of Science, Technology and Philosophy in the Eighteenth Century.* By A. Wolf, Professor and Senator, University of London, and Head of the Department of History and Philosophy of Science. 345 Illustrations. 814 pp. $8.00. The Macmillan Company.

ing contributions to mathematics, mechanics, astronomy, astronomical instruments, magnetism and meteorology. Dr. Eric Bell refers to him as a scientific giant of his day. Yet Professor Wolf refers to Gauss only three times, and in each case almost incidentally. This scant reference to one of the greatest scientists of the century under discussion is mentioned to illustrate the fact that no man covering so many vast fields can treat each of them with the perspective of a specialist in it. That defect, if it is a defect, is inevitable in all such ambitious undertakings. On the other hand, the writer on so many subjects treats all except those in which he may be a specialist with the enthusiasm and freshness of the amateur. These desirable qualities may more than offset for the general reader any minor errors as to facts or differences in point of view from specialists.

The history by Professor Wolf will undoubtedly be a valuable reference book. Although it is necessarily filled with many names and with references to a multitude of advances in science during a period of its rapid unfolding, it is systematically arranged, clearly written and generously annotated. The reader can get from it a clear idea of the advances in any field of science during the century, he will learn the names of the great contributors to it and he will be informed of important sources of detailed information. But very few persons, if any, would find their interest sustained while reading the entire book.

F. R. M.

NATURE—IN ONE BOOK[1]

NATURE study is more than the study of nature. Beginning with simple, yet accurate observation, it organizes the knowledge so gained on a growing framework of understanding. At the same time, it encourages interest, liking and creative thought. In so doing, it links science with art and develops the individual's ability to enjoy the world. Nature study may begin with beetles or beans, but almost at once it tackles the task of improving human beings.

This view of nature study has been set forth by Bertha Stevens and a few other writers. Their books, however, only define attitudes and objectives. The actual methods of teaching or study, and the information to be gained, must be found in other volumes.

The foremost of these is Mrs. Comstock's *Handbook*. For 28 years, it has been a standard guide and reference, providing more—and more varied—information than is to be found in any other volume. From plants to mammals and from snowflakes to stars, it has given generations of users an understanding of, and enthusiasm for, things that count in the natural world.

Twenty-three printings, however, left the *Handbook* worn and out of date. These faults have been remedied in this new edition, which has been completely remade by a corps of specialists who still have kept Mrs. Comstock's flavor in writing. The specialists have brought the book up to the minute in information, have added extensive and very serviceable bibliographies, and have contributed hundreds of new illustrations. To accommodate these changes, the page size has been increased, the quality of paper improved, and the type reset in two columns. The result is a durable, attractive book whose price makes it a rare bargain.

More important, however, is the *Handbook's* all-round utility. Teachers and parents will find it a guide and sourcebook; interested adults may use it for identification; scientists will find it a guide to non-technical literature. In short, the *Handbook* is the most useful survey of nature in our northeastern states and eastern Canada now in print.

C. L. F.

[1] *Handbook of Nature Study*. By A. B. Comstock. Illustrated. xx + 937 pp. Revised Edition. $4.00. Comstock.

THE PROGRESS OF SCIENCE

DR. FRANK B. JEWETT, PRESIDENT OF THE NATIONAL ACADEMY OF SCIENCES

THE breadth of view of the leading scientists of the United States is illustrated in the unanimous election of Dr. Frank B. Jewett, an engineer, for a four-year term as president of the National Academy of Sciences at its recent annual meeting in Washington.

The Engineering Section of the academy, created in 1918, is the newest of the eleven sections covering the mathematical, physical and biological sciences. Dr. Jewett is the first engineer to be given a place in the distinguished roll of the academy's presidents, which includes such names as Alexander Dallas Bache, Joseph Henry, Wolcott Gibbs, Alexander Agassiz, Ira Remsen, William Henry Welch and other more recent ones.

The academy has always maintained the conception of the unity of science and has set store on the reciprocal illumination that one branch of science sheds upon another, on the theory that the scientific process is so fundamental to them all that the various branches have more in common than they have in their own separate fields.

In this catholic spirit, members of the Section of Astronomy participate equally with members of the Section of Anthropology and Psychology, and all the other sections, in the election of new members to the academy, irrespective of the fields from which the new members come.

The election of an engineer for president is a recognition of the fact that science is the foundation also of engineering. This truth is illustrated by Dr. Jewett's career. As president of the Bell Telephone Laboratories and vice-president of the American Telephone and Telegraph Company in charge of research and development, he has been identified with the progress of pure science and in support of its promotion and of the development of research to an extent unequaled by any other engineer.

Besides his activities in the field of science, he has had the benefit of an unusual industrial experience, in having been chief engineer of the Western Electric Company, and later vice-president in charge of its large manufacturing operations.

Formerly chairman of the Division of Engineering and Industrial Research of the National Research Council, and familiar with that important agency of the National Academy of Sciences for bringing to bear in the national defense all the scientific and engineering resources of the country, he will be in a position to bring out the utmost usefulness of the academy itself to the government under the requirements of its charter, and to align the National Research Council and its engineering connections, in the event that the war services of the academy should again be called upon.

Dr. Jewett is a bachelor of arts graduate of Throop Polytechnic Institute, now the California Institute of Technology, and he took his Ph.D. in physics at the University of Chicago in 1902. He entered the telephone business in 1904, and to the solution of the great problems attending the growth of the telephone art he brought a rare mind trained to scientific procedure with which was coupled a gift as an organizer and administrator and a capacity for inspiring enthusiasm and friendships.

As a lieutenant colonel in the Signal Corps during the war, he directed the development of communication devices for both the Army and the Navy, and he was one of four members of a special advisory board on submarine detection.

—*Blackstone Studios*

DR. FRANK B. JEWETT

He was also a member of the State Department Special Committee on Submarine Cables.

He has received many honorary degrees, among them doctor of science from New York University and Dartmouth College, in 1925; from Columbia University and the University of Wisconsin, in 1927; from Rutgers University, in 1928; from the University of Chicago, in 1929, and from Harvard University, in 1936. He received the honorary degree of doctor of engineering from Case School of Applied Science, in 1928, and the honorary degrees of doctor of laws from Miami University, in 1932, and from Rockford College, in 1939.

The Edison Medal of the American Institute of Electrical Engineers was awarded to him in 1928; in 1935, the Faraday Medal of the Institution of Electrical Engineers of Great Britain; in 1936, the Franklin Medal, and in 1938, the Washington Award of the Western Society of Engineers. His latest honor was the award of the John Fritz Medal, in 1939. He was also a member of the Science Advisory Board, to which he was appointed by President Roosevelt.

His scientific memberships are numerous. He is also a former president of the American Institute of Electrical Engineers, a trustee of the Carnegie Institution of Washington, the Woods Hole Oceanographic Laboratory and the Tabor Academy at Marion, Massachusetts.

Besides these connections, he is president and trustee of the New York Museum of Science and Industry, to which he has contributed a remarkable development, and he is a life member of the Massachusetts Institute of Technology Corporation.

The action of the academy in putting an engineer at its head will tend to amalgamate the forces of science and of engineering to an extent greater than ever before.

GANO DUNN

ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES

THE seventy-sixth annual meeting of the National Academy of Sciences was held on April 24, 25 and 26, at the Academy Building on Constitution Avenue, in Washington, D. C. One hundred and thirty-two members, including one member emeritus, were present; also four foreign associates. Many of the papers were necessarily somewhat technical in character; but, as a rule, they were presented in a form understandable to the scientific audience. Academy members realize that it is less easy to read a paper before the academy than before a technical society whose members are familiar with the details of the special field of research and with its technical expressions; they seek, therefore, to emphasize only the major results of their investigations and to state their significance in language easily understood.

Forty-five papers were presented. Their distribution among the different sciences was: mathematics, 3; astrophysics, 2; physics, 12; engineering, 1; geology, 2; meteorology, 1; biophysics, 8; biochemistry, 3; botany, 2; physiology, 5; pathology, 1; psychology, 1; history, 1; biographical memoirs, 3. Thirty-three papers were given by members, two by foreign associates, and ten by non-members. Two of the papers were read by special invitation. The great preponderance of papers on problems in physics, astrophysics, biophysics and biochemistry is an indication of the intense activity in these branches of science.

Drs. I. S. Bowen and A. B. Wyse presented the results of measurements of three spectra of the brightest planetary nebulae. They found more than 50 new spectral lines, of which they identified nearly one half. Computations based on the intensities of the spectral lines from

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one of the nebulae showed that its chemical composition is similar to that of our sun.

Drs. A. H. Compton, M. Schein and P. S. Gill deduced from cosmic-ray data obtained in the northern and southern hemispheres of the Pacific Ocean a relation between cosmic-ray intensity and the thermal expansion of the atmosphere. Their data of observation show that the temperature coefficient of cosmic rays is less in equatorial regions than elsewhere, in accord with Blackett's predictions, based on Yukawa's hypothesis that mesotrons are produced in the upper atmosphere by less penetrating radiation, and show spontaneous disintegration similar to radioactivity. The calculations indicate that at latitude 38° the production of mesotrons is a maximum at about 42 kilometers altitude, corresponding to the abrupt change in the latitude effect; the seasonal variation in cosmic-ray intensity accords closely with the variations in latitude at which mesotrons are produced and confirm Blackett's predictions.

Drs. R. A. Millikan and V. H. Neher reported likewise upon seasonal changes in cosmic-ray intensities and found in higher latitudes the same increase of 2 to 4 per cent. in winter, but no appreciable change in the equatorial belt. Their measurements at very high elevations showed, however, much greater percentage changes and seem not to be in agreement with Blackett's hypothesis.

Dr. R. W. Wood described a new spectrograph method, based on the use of a special grating and special prisms, for ascertaining the radial velocities of stars.

Dr. Homer Dudley reported upon the results of work on the automatic synthesis of speech by electrical methods and illustrated the procedure and results by suitable phonograph records. The artificial speech was intelligible and reproduced well the inflection and timbre of the original.

In an invited paper on the active uptake of ions by organisms, Dr. August

Krogh described series of observations on fresh-water animals in which specialized mechanisms take up certain ions from the outside solution and concentrate them 100-fold in the blood. Separate mechanisms were found for kations and for anions. The suggestion was made that all these mechanisms are closely related; but thus far the nature of the process is not understood.

Dr. Douglas Johnson proposed a hypothesis of submarine canyon origin in which the chasms are ascribed to the action of water from submarine springs emerging along the seaward face of the continental shelf. These springs are fed by waters moving under artesian pressure through the sedimentary strata of the shelf and along planes of weakness.

Drs. C. E. Seashore and E. P. Horne described experiments on the function of the mute on the violin. They found that the weight of the mute is the chief factor in reducing the total intensity of the tone not in the fundamental, but in the partials at various levels. The change of harmonic structure varies with the string, the pitch level, the character of the violin and the mute itself.

Drs. D. A. MacInnes and L. G. Longsworth reported upon electrophoretic studies on blood sera with the aid of a modification of the Tiselius apparatus in which changes in refractive index in the electrophoretic boundaries are automatically recorded. These records indicate the number, the mobilities, the amounts and the relative homogeneities of the proteins present. Pathological sera disclose abnormalities and departures from normal sera; the method promises to be useful in diagnosis.

On Monday evening the first Pilgrim Lecture to be given in this country was delivered by Sir William Bragg, president of the Royal Society and director of the Royal Institution. The lecture was the first one delivered in America under the six-year cooperative agreement between the Royal Society and the Na-

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tional Academy of Sciences, providing that a lecture shall be given each second year before the Royal Society by an American scientist selected by the Royal Society, and each alternate year before the National Academy of Sciences by a British scientist selected by the academy. Funds in support of the lectureship were contributed by the Pilgrim Trust of Great Britain, a foundation established by Edward S. Harkness, of New York. The first Pilgrim Trust Lecture was given by Dr. Irving Langmuir in December, 1938, before the Royal Society. Sir William Bragg, on invitation by the National Academy of Sciences, delivered the second lecture of the series and chose for his subject "History in the Archives of the Royal Society."

In his address, Sir William traced the gradual change and growth of science since the incorporation of the Royal Society in 1662. The Royal Society has received and carefully preserved a very large number of papers and documents on scientific and other subjects, which reflect the development of science during the centuries and illustrate the changing attitude of society toward science. In the early years of the Royal Society the experimental science of its founders was simple and interested the entire membership; as knowledge increased, specialization became necessary and with it the adoption of technical terms and expressions in different fields, with the result that at present a scientist can encompass only a limited portion of scientific knowledge. The relation between science and human society has gradually become less immediate, but at the same time more important. Serious efforts are being made to lower this barrier of specialization by interpretation of the results of research in science to non-specialists. Sir William illustrated the progress of growth of science through excerpts from the society's archives and emphasized the responsibility that rests upon scientists not only to advance knowledge by

experiment but, by clear exposition, to acquaint others with these advances and with the scientific approach to problems as they arise, thereby greatly enhancing the human value of their efforts.

On Tuesday afternoon seventy academy members and guests visited the Supreme Court of the United States and listened to the presentation of a case before the court. After its adjournment, Justice Harlan F. Stone welcomed the group in a brief address and described the several features of special interest in the new building. The party was then shown over the marble structure and admired its architectural beauty, its winding staircases and its library facilities. The visit was extremely interesting and was much appreciated by the members.

At the annual dinner of the academy, on Tuesday evening, President Lillie reported upon the activities of the academy during the past year. In his address he referred to the functions of the academy in its relation to the government and to certain problems on which the government has requested advice; also to the work of the National Research Council. To quote from his address:

> The Academy has adhered very consistently since its incorporation to the principle that the primary consideration for membership is convincing evidence, by scholarly character and productiveness, of devotion to the fundamental principles of science and the scientific way to knowledge, which are the sources of the discoveries and inventions that have transformed the social and economic conditions of modern life. There is no danger that we should depart from these principles. But it should be widely known that we fully recognize the social, economic, and national responsibilities that rest upon us, and that we are making every effort to discharge these responsibilities. The Academy occupies a very special position of responsibility in the relations between science and public affairs.
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> From the state of being largely ignored as a social and economic factor, science has in my own lifetime reached the condition of credit for complete transformation of the social and economic conditions of modern life, and this arouses expectations of new discoveries that will quicken old and create new industries, that will protect

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ASSOCIATE PROFESSOR OF ANTHROPOLOGY, SCHOOL OF MEDICINE, JOHNS HOPKINS UNIVERSITY.

DR. W. B. CASTLE
ASSOCIATE PROFESSOR OF MEDICINE, HARVARD MEDICAL SCHOOL.

us in time of war, that will improve the health of the people and its innate qualities, and that will enable governments better to discharge their almost infinitely complex responsibilities.

It is unthinkable that the National Academy of Sciences should not respond to the utmost of its capacities. Created as it was to advise the agencies of the Federal government on any subject of "science or art," and pledged as each member is to render his services to the government without any compensation whatever, the present grave time calls for a renewed dedication to the service of our country. Our government expects and is entitled to this service from us by the very Articles of Incorporation.

DR. PHILIP E. SMITH
PROFESSOR OF ANATOMY, COLLEGE OF PHYSICIANS AND SURGEONS, COLUMBIA UNIVERSITY

The intention of the creators of the Academy was not, however, to establish another bureau under government control—either in the minds of the government or of the founders themselves—it was, on the contrary, to establish a free and independent body, with complete control over election to membership, that could be relied upon to advise without bias or fear. For this reason the no-compensation clause, to which I have alluded, was introduced; and for this reason the Academy has neither sought nor received financial support from the government.

At the conclusion of his address Presi-

dent Lillie awarded, on behalf of the academy, four medals:

The Agassiz Medal for Oceanography to Harald Ulrik Sverdrup, of the University of California; the Daniel Giraud Elliot Medal for 1933 and accompanying honorarium of $200 to Richard Swann Lull, of the Peabody Museum of Natural History, Yale University; the Daniel Giraud Elliot Medal for 1934 and accompanying honorarium of $200 to Theophilus Shickel Painter, of the University of Texas; the John J. Carty Medal and award for the advancement of science, consisting of a gold medal, bronze replica, certificate and $3,000 in cash, to Sir William Bragg, of the Royal Institution, London.

At the business session of the academy, Dr. Frank B. Jewett, president of the Bell Telephone Laboratories and vice-president of the Bell Telephone Company, was elected president of the academy for a term of four years, beginning July 1, 1939, to succeed Dr. Frank R. Lillie, emeritus professor of zoology at the University of Chicago. Dr. F. E. Wright, of the Geophysical Laboratory, Carnegie Institution of Washington, was reelected home secretary for a term of four years. Dr. Charles August Kraus, professor of chemistry at Brown University, and Dr. Alfred Newton Richards, professor of pharmacology at the University of Pennsylvania, were elected members of the council to succeed Dr. Simon Flexner, director emeritus of the Rockefeller Institute for Medical Research, and Dr. J. B. Whitehead, director of the school of engineering of the Johns Hopkins University.

Fifteen men were elected to membership in the academy:

Gregory Breit, University of Wisconsin.
Detlev W. Bronk, University of Pennsylvania.
W. B. Castle, Harvard Medical School.
F. G. Cottrell, Research Corporation.
Frederick P. Gay, College of Physicians and Surgeons, Columbia University.
A. Baird Hastings, Harvard University.
Vladimir N. Ipatieff, Universal Oil Products Company.
M. H. Jacobs, University of Pennsylvania.
Zay Jeffries, General Electric Company, Cleveland, Ohio.
D. F. Jones, Connecticut Agricultural Experiment Station.
George B. Kistiakowsky, Harvard University.
W. J. Mead, Massachusetts Institute of Technology.
Oscar Riddle, Station for Experimental Evolution, Carnegie Institution of Washington.
Adolph H. Schultz, School of Medicine, Johns Hopkins University.
Philip E. Smith, College of Physicians and Surgeons, Columbia University.

Three foreign associates were elected:

Sir Joseph Barcroft, professor of physiology, the University of Cambridge, England.
Sir William Bragg, director, the Royal Institution of Great Britain, and director, the Davy-Faraday Research Laboratory, London, England.
Dr. F. A. Vening Meinesz, professor of geodesy and cartography, the University of Utrecht.

The present membership of the academy is 304, with a membership limit of 350; there are six members emeriti. The number of foreign associates is 42, with a limit of 50.

The autumn meeting of the academy will be held this year on October 23, 24 and 25 at Brown University, Providence, R. I.

F. E. Wright,
Home Secretary

MILWAUKEE A MECCA FOR SCIENTISTS IN JUNE

At the beginning of the third week of June Milwaukee will be a mecca for eminent men from nearly all the major fields of science, for from June 19 to 24, inclusive, the American Association for the Advancement of Science will hold, in the Wisconsin metropolis, its one hundred fourth meeting.

Unlike the Mohammedans, scientists have many places at which they assemble for their communions—at Denver in June, 1937, at Indianapolis in the following December, last June in Ottawa, last December in Richmond, and now in Milwaukee. To scientists it is not a place, but Truth, that is sacred. To

them inspiration does not come down from authority but from the ardent fires in their own minds. They are not attempting to perpetuate fixed doctrines but eagerly and enthusiastically to explore new regions. They do not impose their ideas by the use of force but only by appealing to experience and reason. They do not dream of some distant Paradise but are happy now in working to produce one here on the earth.

The American Association for the Advancement of Science is the greatest integrating force in science in this country, perhaps in the world. In its own organization it has 15 sections, which together cover practically all of science. In addition, 169 scientific societies and organizations are affiliated with the association. There are corrective influences at work when scientists from different fields meet together. Horizons are broadened. Perhaps a more pertinent figure of speech is that when different scientists mingle there are cross fertilizations of ideas that are no less creative than are cross fertilizations in biology.

One of the important features of meetings of the association is comprehensive symposia on subjects which often run freely across the boundaries that circumscribe the various sciences and sometimes hinder their growth. For example, geologists, geographers and engineers will devote Friday, June 23, to soil conservation. The zoologists and the botanists, on June 20, will hold a joint symposium on "The Relation of Genetics to Geographical Distribution and Speciation."

Perhaps the symposia of greatest interest to the general public are the two that will be presented by the section on the social and economic sciences. One of these symposia, consisting of eight sessions, is on population and planning activities in the Northern Lake States. The other, consisting of five sessions, is on "The Economic System in Relation to Scientific Progress." The first of the ten papers in this program is on "The Capitalistic System and How It Evolved"; the topic of the last session, at which two papers will be presented, is "Government and Science." In these disturbed days these are interesting questions. The general public will be admitted to these sessions, as well as to all others at Milwaukee, and the principal addresses delivered will be followed by discussions from the floor.

It is an interesting commentary on science that scientists on the whole are not seriously apprehensive of the future. With the long ascent of man throughout the geological ages in the background of their consciousness, they have confidence in the vitality and adaptability of human beings and that they will survive the storms that threaten.

At each summer meeting the association provides an address by a distinguished scientist on some subject of general interest. This year the Maiben lecture, as it is known after the founder of the lectureship, will be delivered by Dr. Victor G. Heiser, author of "An American Doctor's Odyssey."

All the sessions of the Milwaukee meeting will be held from Monday, June 19, to Saturday, June 24. The meteorologists will meet on Monday and Tuesday; the chemists on Monday to Wednesday (Tuesday and Wednesday at Madison); the geologists and geographers, including their field trips, the entire week; the zoologists, on Tuesday, Wednesday and Thursday; the botanists on Tuesday; the ecologists, Tuesday to Thursday; the anthropologists, Tuesday to Thursday; the social scientists and economists, from Monday to Friday; the engineers, on Friday; the medical men, on Monday to Thursday; the foresters, including field trips, Monday to Sunday; the educationists, on Friday.

F. R. MOULTON,
Permanent Secretary

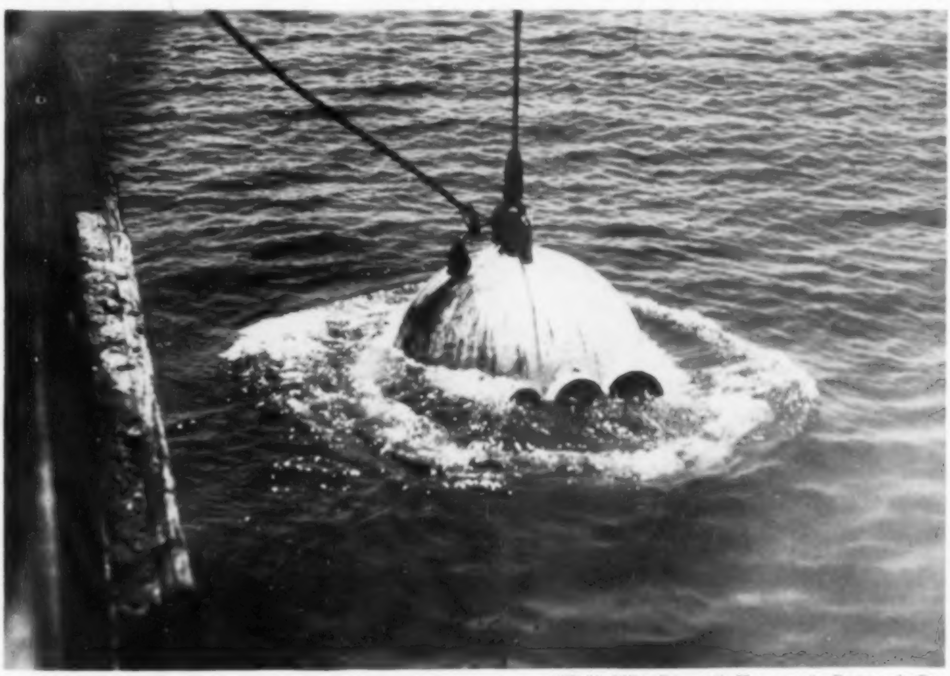
BIOLOGY AT THE NEW YORK WORLD'S FAIR

THE New York World's Fair offers for the student and teacher of biology a living laboratory rich in materials and unique in presentation. There are several buildings completely devoted to the biological sciences—notably the Hall of Man, the Medicine and Public Health Building, the food exhibit and the building of the New York Zoological Society. But the entire fair illustrates the pervasive role of science in general and biology in particular. In scores of the industrial buildings there are exhibits of special interest to the biologist. With the exception of the New York Zoological Society display, which charges a nominal fee, all the exhibits are free.

The Hall of Man, inscribed with the quotation from the Confessions of St. Augustine,

> Man wonders over the restless sea
> The flowing water
> The sight of the sky
> And forgets that of all wonders
> Man himself is the most wonderful,

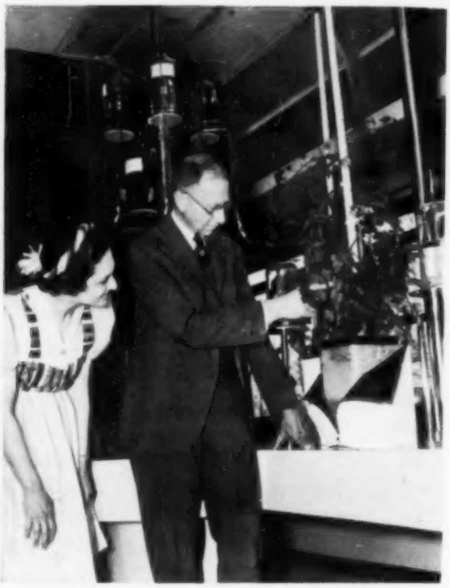
is completely devoted to normal biology. The exhibit sponsored by the American Museum of Health and advised by a committee chaired by Dr. Livingston Farrand, was visited on the opening day alone by 59,348 people. There are displays of Spalteholz specimens, which were contributed by the Oberlaender Trust of Philadelphia. These actual human structures, rendered transparent by an oil immersion process, are ingeniously arranged in their relative positions in eight large cabinets upon which is painted the figure of a human body. There are also transparent specimens of the different animal phyla. The entire process of mitosis is graphically demonstrated by means of large glass models of cells in which both the chromosomes and spindle fibers can be seen. Beautiful models and transparencies of blood



—*"Half Mile Down," Harcourt, Brace & Co.*

THE BATHYSPHERE

IN WHICH DR. WILLIAM BEEBE DESCENDED ONE-HALF MILE INTO THE OCEAN. IT IS BEING DISPLAYED AT THE FAIR IN THE BUILDING OF THE NEW YORK ZOOLOGICAL SOCIETY.



THE GROWTH OF A TOMATO PLANT
DEMONSTRATED BY DR. J. W. SHIVE OF THE NEW JERSEY AGRICULTURAL EXPERIMENT STATION IN THE HEINZ LABORATORY AT THE FAIR.

cells as well as a striking presentation of blood groups according to the Snyder classification can be found in the Hall of Man. A large model of a brain studded with push buttons attached to figures of various functions which light up dynamically illustrates brain localization. Upon entering the hall a twenty-foot figure of a man is heard, as well as seen, since there is an amplified recording of the heart beat. One exhibit, which visitors wait in long lines to see, consists of models of a fetus in utero and the process of delivery. There are huge models of a tongue and the taste buds, the ear, the eye, and a table by which the visitor can demonstrate for himself various smell sensations by combining the three fundamental odors. Because of the many visitor-participation items, this is not the usual museum but a new type of laboratory which, judging from the interest of the participants, is proving a remarkably effective method of teaching.

The Hall of Medical Science consists of more than thirty-five large exhibits sponsored by various laboratories and scientific associations. One of the outstanding demonstrations is of the Carrel-Lindbergh perfusion apparatus, personally checked by Dr. Alexis Carrel at the fair on Friday, May 5. The dog's thyroid now in the perfusion chamber is expected to outlast the fair.

The story of allergy is simply but clearly told—the causative agents, the types of allergies, hay fever, asthma and eczemas, the water or oil soluble fractions of pollen which cause allergies and the hereditary tendencies are all demonstrated by colored transparencies.

An extremely interesting participation display is that sponsored by the American Medical Association. By a series of buttons and levers operated by the visitor he is briefly shown the subject-matter of nineteen of the medical sciences which are taught in the medical schools. Moving lighted currents illustrate the interdependence of the various hormones and the effect upon specific organs in the endocrine exhibit. A representation of the oestral cycle, goiter distribution maps, and a furnace with a damper opened, closed and at normal, illustrating the influence of the thyroid on metabolic rate, are all high spots of the endocrine exhibit.

The Health and Safety of the Worker Committee has prepared an exhibit showing a few of the occupational diseases and the health hazards in the production of many of the articles in daily use.

An important social consequence of the fair can already be envisaged in many of the displays in this hall. Here simply and clearly the layman is able to obtain accurate information of the latest scientific discoveries. For example, the recent work of Dr. Stanley on viruses, the new membrane method of virus culture, the work on testosterone—the male sex hormone—are all presented. Sulfapyridin, accepted by the American Medical Association in the week of May 5, is described in the section on pneumonia, al-

though used experimentally for over a year. Thus the approval of a therapeutic agent through the fair reaches the physician and the layman at the same time.

The New York Zoological Society's building illustrates some of the activities of its three major departments—the Zoo, the Aquarium and the Department of Tropical Research. The actual Bathysphere in which Dr. William Beebe descended into the ocean off the coast of Bermuda is in the Bathysphere-shaped building, the walls of which contain many deep sea forms which fluoresce under an ultra-violet light. In a relatively small space the visitor gains a tremendously broad scope—life from the depths of the sea to the mountain tops of Tibet, as exemplified by the giant panda, from the saber-toothed tiger and the mastodon to man, from the brilliantly colored tropical fish and birds, "the Crown jewels," to the leaf-cutting ants, a diorama of the sinking of the Hudson Gorge, an Austral-Asian habitat group—all these are designed to persuade the normal man of the breadth and dynamics of biology.

In the Food Building constructed by the fair there is a section dedicated to the illustration of the formula, "Man equals chemicals equals Food." Vitamins and the deficiency diseases are portrayed. The New York City Building is peppered with biological material. As the visitor rounds a corner he views the monkeys and birds in the small zoo. In the exhibit of the New York Botanic Gardens a large model of Krubi, the eight-foot flower of Sumatra, opens and closes. The American Museum of Natural History display, backed by a replica of a section of the Planetarium, consists of several miniatures of the habitat groups, the originals of which are to be found in the halls of the museum. A huge chameleon atop a pedestal, bearing a large transparency of a cross section of the skin and explaining the action of

PROTOZOA PROJECTED ON THE SCREEN
A DRAWING OF ONE OF THE EXHIBITS SHOWING DR. GEORGE ROEMMERT SILHOUETTED AGAINST ONE OF TWELVE SCREENS IN THE MICROVIVARIUM.

the chromatophores in producing color changes, is found in the foreground.

Behind the ideas of the singing tower, the time capsule and Moto—the mechanical man—there is a vast amount of biological material in the Westinghouse Electric Building. A microvivarium, directed by Dr. Georg Roemmert, consists of a semi-circular darkened gallery containing twelve screens five feet in diameter. Here protozoa, hydra and rotifers magnified 2,000 times are seen swimming about. A demonstration of the Sterilamp—a new type of ultra-violet lamp—and its bactericidal properties is also demonstrated in this microvivarium. General Motors also has a microvivarium in which one sees molds and mixed protozoa culture.

Of extreme interest to the teacher of biology is the hall devoted by the Westinghouse Company to the American Institute's science and engineering clubs. Here are dioramas of plant propagation, the evidences of evolution models of protozoa in which the same color is used for

the contractile vacuole in several forms, another color for the nucleus, etc., and here is a laboratory where students are working on hydroponics, demonstrations of which are also seen in the Heinz exhibit and Gardens on Parade.

A lethal chamber, testing the killing time of various solutions on house flies, a termite colony, a group of Mexican bean beetles happily feeding on sprayed and control plants, are all features of a display in the du Pont company building.

A large glass-enclosed working dairy laboratory, in which technicians are performing all the routine tests of milk examination, is found in the exhibit of the Sealtest Company.

For the specialist, the Department of Science and Education conducts an information service. Here will be classified, according to scientific subject, all the items of scientific interest. There is an auditorium in this building in which scientific and medical motion pictures are shown and which is available for meetings of scientific organizations.

GERALD WENDT,
Director of Science and Education

BOK PHOTOGRAPHIC MUSEUM OF THE FRANKLIN INSTITUTE

THE new Cary W. Bok Photographic Museum of the Franklin Institute was opened early this year, the centennial of Daguerre's announcement of the first successful photographic process. The purpose of the section is threefold: to tell the history of photography; to explain the basic principles of apparatus and the various processes of producing photographs; and to show examples of fine photography, both pictorial and scientific.

The visitor enters the section through a gallery arranged to show approximately one hundred photographs. Here, the effective and novel system of illumination immediately strikes him. The prints are illuminated from above by concealed lighting, using the new General Electric daylight fluorescent tubes, mounted in special reflectors which direct the light down along the wall, without allowing it to spread back more than about two feet into the room. Thus no direct light strikes the visitor (there is no other light in the gallery) and reflections on the glass are reduced to a minimum.

—*Gladys Müller*

A VIEW ACROSS THE EXHIBIT HALL SHOWING SAMPLES OF EARLY PHOTOGRAPHY

Each month the prints on display are changed. One-man shows by outstanding photographers and collections from various societies and clubs are being exhibited. Steps are being taken to build up a fine permanent collection.

Two doors lead from this gallery into the remainder of the photographic museum, the first into a small studio designed to illustrate principles of correct portrait lighting. Here the visitor can take pictures of his own model with his own camera under ideal conditions. A camera stand is provided, and, at present, three different lighting arrangements, controlled by interlocking switches, are available. Framed examples of portraits made in the studio are mounted near the switches. Only the lowest priced reflectors are used, to encourage the visitor to attempt similar work at home.

The second door from the gallery leads to the balcony around the second floor Graphic Arts section, a hall 88 feet long and 24 feet wide, which forms the main exhibition space for the section. On entering the door, the visitor faces a blank wall in the center of which is a two-foot square ground glass. On this screen appears an inverted image of the opposite end of the room, formed by a lens of three-foot focal length built into a large camera on the other side of the wall. Turning to the left, he finds various exhibits explaining the formation of images, and the development of the camera obscura before the invention of photography.

The simplicity of photography is demonstrated by an exhibit comparing photographs made using a camera constructed at a cost of nineteen cents with pictures of the same subjects using elaborate and expensive equipment. The portraits and landscapes displayed show clearly that fine pictures of some subjects can be made with very simple equipment.

Exhibits consisting of thirteen units operated by push-buttons are used to show the optical properties and defects of simple lenses. Actual images are formed by lenses on ground-glass screens, and the objects projected are chosen to bring out the points being explained. The various defects of lenses, such as spherical aberration, coma, etc., are presented. Another exhibit of six units explains the meaning of F numbers and five units are used to show how depth of focus depends on the aperture and the focal length of the lens used. The same principles are used in showing the development of the camera obscura and the action of a lens in forming an image.

—*Gladys Müller*

THE AMATEUR PHOTOGRAPHIC STUDIO

WHERE THE VISITOR CAN TAKE PICTURES USING HIS OWN MODEL AND CAMERA. THERE ARE THREE DIFFERENT LIGHTING ARRANGEMENTS WITH WHICH HE CAN EXPERIMENT.

Another group of exhibits is concerned with exposure. Here a large collection of exposure meters is shown, and an exhibit dealing with the determination of correct exposure is under construction. The results of correct and incorrect exposure, as well as various examples and causes of good and bad prints, are shown by means of a series of negatives and prints from them.

On exhibit at the present time is a portion of a very fine collection of historical items, including the oldest camera in America. It is intended to further emphasize the history of photography, especially the very important part played by Philadelphia in the development of the art.

Also, the institute has on display an unusual collection of early motion picture apparatus. In the future exhibits will be added to explain motion pictures.

WAGNER SCHLESINGER

AERONAUTICAL RESEARCH AND DEVELOPMENT

INTERNATIONAL developments of the past year, and the steps now under way to augment the size and effectiveness of our aerial defences, make particularly appropriate a consideration of what this country is doing from the scientific point of view to improve the quality of the equipment used by its flying services.

Size alone of an aerial military force is a minor factor in determining its efficiency as compared with that of possible opponents. Coupled with airplanes and accessories of the highest order must be an operating force adequately trained to handle them, together with repair facilities and the myriad of items which are necessary to "keep the planes in the air."

It has been truthfully said that the airplane of the present day does not differ fundamentally from its predecessor of 1914. There has, however, been a steady improvement in performance. While a speed of 60 miles per hour was considered satisfactory in the earlier days, no plane of the fighting or pursuit type is considered for future development with a speed not in excess of 400 miles per hour, while engineers are already talking of a 500 miles per hour ship. These results, which have been steadily achieved from year to year, have been obtained primarily through engineering research. Apparently minor details, such as the setting of rivet heads flush with the skin of the ship, have added miles per hour to speed.

This engineering research may be divided into three separate classes, which may, however, in certain cases show a small amount of overlapping. First, is what is generally known as fundamental research. This is carried on in the United States in the laboratories of the National Advisory Committee for Aeronautics, located at Langley Field, Virginia. The results of these investigations are then considered by the Army experimental plant at Wright Field, and applied to military aircraft, both of the Army and the Navy.

The third class of research is that carried on by civilian institutions, such as some of the leading technical schools, which possess the necessary equipment. This is used by the aeronautical industry located in close proximity, for the purpose of solving problems in connection with the design of specific airplanes, although a certain amount of the work is sometimes performed by the manufacturing plants themselves.

Research is not confined to airplanes alone, but to such related things as engines, fuels and instruments. And it must not be forgotten that research which is at first directed primarily toward the development of military airplanes and accessories is bound to be reflected also in the improvement of civil aircraft.

While a few years ago the United States led the world in the quality of its aircraft, this leadership since then has been diminishing. A number of the European nations have greatly augmented their research facilities. For example, as compared with our single basic laboratory at Langley Field, Germany now possesses no less than five, one of which alone employs a personnel several times the size of that of the N.A.C.A.

We have been taking steps to improve our position. We are greatly expanding the Army plant at Wright Field, and hope to spend more than $6,000,000 in aeronautical research and development alone.

While we have lost ground within the last few years we have not been idle, but, even though limited in funds, have been remarkably successful in many experimental projects. The United States possesses engineering skill and brains equal to those anywhere in the world. With the additional facilities which are being asked for, there seems to be no reason why we should not be able to regain the ground which has been lost, and once more lead the world in aeronautical development.

HENRY H. ARNOLD,
Chief of the U. S. Army Air Corps

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